"NATURE", APRIL 18, 1959

DESK

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NATURE

A Weekly Journal of Science

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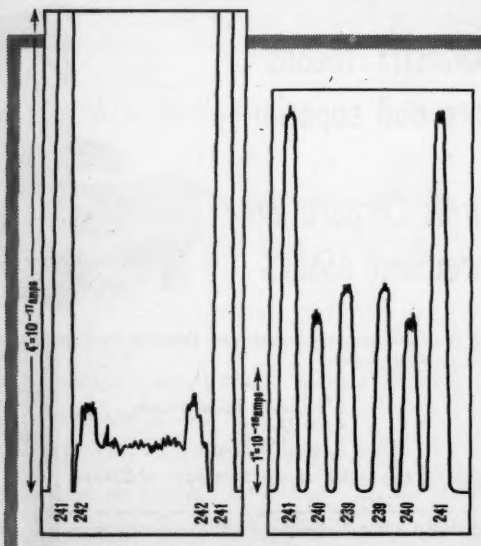

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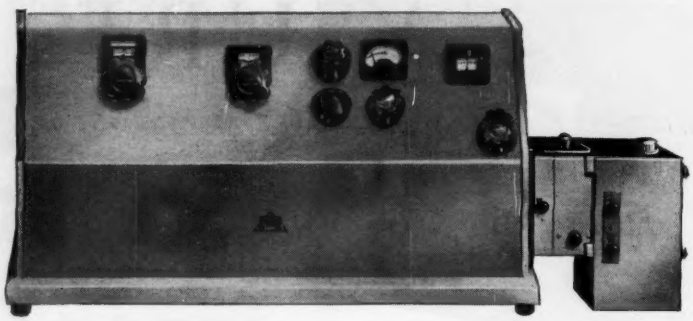
NATURE

No. 4668 SATURDAY, APRIL 18, 1959 Vol. 183

CONTENTS

	Page
The Need for a Balanced Education	1075
Queen and Servant of the Sciences. By W. J. Langford	1076
Atomic Comforts. By Prof. G. O. Jones	1077
Quadrupole Resonance. By Dr. R. H. Tredgold	1078
Rational Discussion. By Dr. E. H. Hutten	1078
Natural History of British Spiders. By Dr. Eric Duffey	1079
Carbohydrates Complete. By Prof. M. Stacey, F.R.S.	1079
Aboriginal Art. By Dr. Phyllis Kaberry	1080
The Zoological Society of London. By Sir Solly Zuckerman, C.B., F.R.S.	1082
Shorewards Upslope of the Layer of Minimum Oxygen off Bombay: its Influence on Marine Biology, especially Fisheries. By Dr. J. N. Carruthers, S. S. Gogate, J. R. Naidu and T. Laevastu	1084
Russian Contributions to the International Geophysical Year. By Dr. N. A. Routledge	1087
Obituaries:	
Prof. Wolfgang E. Pauli, For.Mem.R.S. By Prof. N. Kemmer, F.R.S.	1089
Prof. A. C. Pigou. By the Right Hon. Philip Noel-Baker, M.P.	1089
News and Views	1090
Hypersonic Flow. By B. E. Beadle	1095
Interfacial Phenomena. By Dr. J. Nutting	1097
The Colombo Plan	1099
Bear Island Cod. By N. B. Marshall	1100
Progress in British Forestry. By Sir Harry Champion, C.I.E.	1100
Formation of Aberrant Cell Walls and of Spores by the Growing Yeast Protoplast. By A. A. Eddy and D. H. Williamson	1101
Cæsium-137 in Swedish Milk and Soil. By K. Löw and K. Edvarson	1104
Hair Receptors in Locusts. By Dr. L. J. Goodman; Dr. P. T. Haskell	1106

(Continued overleaf)



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LETTERS TO THE EDITORS

Page

CHEMISTRY

Enhancement of Radiation-induced Cross-linking of Polyvinyl Chloride.—Dr. S. H. Pinner . 1108

Adhesion and Ion-Exchange between Mica Surfaces.—George L. Gaines, jun. 1109

Material Transfer in Monomolecular Layers of a Boundary Lubricant.—George L. Gaines, jun. 1110

A New Method of Integration Recording.—Allen Strickler and Dr. William S. Gallaway . . 1110

PHYSICAL SCIENCES

Conductivity induced by Radiation in Polycrystalline Cadmium Sulphide and Polyethylene.—C. G. Clayton, B. C. Haywood and Dr. J. F. Fowler 1112

Refractive Index of Uranium Oxide produced by Anodic Oxidation.—A. E. Stebbens and Dr. L. L. Shreir 1113

Frequency of Meteorite Falls throughout the Ages.—Prof. Hans Pettersson, For.Mem.R.S. . 1114

Chemical Composition of Tektites.—Prof. Harold C. Urey, For.Mem.R.S. 1114

BIOCHEMISTRY

Are Nucleoside Triphosphates Precursors of Mammalian Ribonucleic Acid *in vivo* ?—Prof. Paul Mandel, Jacques-David Weill, Marc Ledig and Suzanne Busch 1114

Stizolobic Acid : a New Amino-Acid in *Stizolobium hassjoo*.—Prof. S. Hattori and Dr. A. Komamine 1116

Structure of Phthiocerol.—Dr. H. Demarteau-Ginsburg, Dr. E. Lederer, Dr. R. Ryhage, Dr. S. Ställberg-Stenhagen and Prof. E. Stenhagen 1117

Changes produced in Serum Lipoproteins of Dogs by Cellulose containing Methyl Groups.—Margaret M. Fröhlich, V. Balázs, K. Kovács and A. Benkő 1119

Gas-Chromatographic Observation of the Reduction of Carbon Dioxide to Methane during Anaerobic Digestion.—J. Chmielowski and Peter C. G. Isaac 1120

'Vapour Toxicity' of Solid Insecticides.—P. Gerolt 1121

Moisture Content of Whole Bread and Bread Crumb.—Y. Pomeranz 1122

PHYSIOLOGY

Excretion of Catechol in Human Urine.—Prof. U. S. von Euler and F. Lishajko 1123

Mechanism of Action of Insulin.—A. Dunn, N. Altszuler, Prof. R. C. de Bodo, R. Steele, D. T. Armstrong and J. S. Bishop 1123

Action of Pyrrolizidine Alkaloids on the Neuro-Muscular Junction.—Dr. C. H. Gallagher and Dr. J. H. Koch 1124

Page

Hæmoglobin of New-born Infants in Indonesia.—Dr. Lie-Injo Luan Eng 1125

Effect of Toxopyrimidine on Glutamic-decarboxylase and Glutamic-oxalacetic Transaminase of Rat Brain.—Dr. G. Rindi, V. Perri and U. Ventura 1126

Effect of Ouabain on Sodium Flux in Human Red Cells.—Thomas J. Gill and Prof. A. K. Solomon 1127

Lithium Retention in Ascites Tumour Mice.—Shirley E. Simon, E. M. Trautner and D. A. Coats 1128

Oxidative Metabolism and Puparium Formation in the Ebony Mutant of *Drosophila melanogaster*.—Alexander Wolsky and Henrietta G. Kalicki 1129

Inhibition of Growth and Respiration of *Ophiobolus graminis* var. *avenae* and *Aspergillus niger* by Cystine.—Elizabeth M. C. Turner . . 1130

BACTERIOLOGY

Formation of 'Protoplasts' in Mutant Strains of *Salmonella* induced by Galactose.—Toshio Fukasawa and Hiroshi Nikaido 1131

Isolation of Two Types of *Pasteurella haemolytica* from Sheep.—Geoffrey R. Smith 1132

Production of 5-Keto-gluconic Acid by a Species of *Pseudomonas*.—D. J. Stewart 1133

Synthesis of Deoxyribonucleic Acid by Phage-infected *Escherichia coli* in the Presence of Mitomycin *C*.—Dr. Mutsuo Sekiguchi and Dr. Yasuyuki Takagi 1134

Synthesis of Cellulose in Ethanol Extracts of *Acetobacter xylinum*.—Dr. J. Ross Colvin . 1135

BIOLOGY

Ultrastructure of Nucleoli in Oocytes of *Patella coerulea*.—A. Bolognari 1136

Lens Cells of the Calf in Continuous Culture.—Dr. J. van der Veen and C. F. A. Heyen . . 1137

Effect of Controlled Lighting on Production Characters in the Fowl.—J. C. Bowman and J. D. H. Archibald 1138

Sex Incidence of Vascular Lesions in Aging Rats in Relation to Previous Pregnancies.—Prof. Theodore Gillman and Michael Hathorn . . 1140

Amniotic Fluid and the Fœtal Lung.—Bernard Towers 1140

Testing Populations of Beet Eelworm, *Heterodera schachtii* Schmidt, for Resistance-breaking Biotypes, using the Wild Beet (*Beta patellaris* Moq.) as Indicator.—Audrey M. Shepherd . 1141

Persistence of Tomato Aucuba Mosaic Virus in Dried Leaf Tissue.—Prof. John Caldwell . 1142

A Third Species of 'Pepper' in West Africa.—J. Yanney Wilson 1142

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THE NEED FOR A BALANCED EDUCATION

IN the fourth of his Reith Lectures on November 30, Prof. A. C. B. Lovell remarked: "The technical devices which form the basis of the present economic and cultural strength of the Great Powers can be traced back within a few generations to fundamental scientific investigations which were carried out in the abstract, supported without thought of direct practical benefit". At least partial realization of this truth is one of the main factors which have been responsible for the steady expansion of the Parliamentary vote in Britain for the universities and for the Government's plans for the expansion of technological and technical education. Nevertheless, the national expenditure on education lags far behind the expenditure on education in the United States and in the U.S.S.R., as well as in other countries. Russian expenditure on education in 1959 is estimated at about £8,420 million, compared with £5,340 million in 1958, with £2,480 million for science and a military budget in 1959 of £8,740 million.

Dr. B. V. Bowden has recently given some comparative figures for the United Kingdom and for the United States, where some 5,000 million dollars are estimated as required in the next ten years to provide facilities for the expected increased undergraduate population; some 300 million dollars of this total is required for science laboratories. The University Grants Committee in Britain deals with twenty-one universities, one university college and two colleges of technology; in addition, there are 153 teachers' training colleges, eight colleges of advanced technology, some thirty-six advanced colleges of art and commerce, half a dozen colleges giving specialized courses, and about a hundred technical colleges giving full-time tuition to senior students. In the United States there are some 1,800 institutions of advanced study, ranging from universities with more than 40,000 undergraduates to colleges with only fifty. While only 9 per cent of the school-children in Britain enter the sixth form of grammar and secondary schools, and between 4 and 5 per cent go to universities or colleges, in the United States nearly all children remain at high school until the age of seventeen or eighteen, and last year 34 per cent of the 18–21 age group enrolled in college.

The probability that an American child will go to college is thus about four times as great as the probability that an English child will enter a sixth form, and the 95,000 students in British universities and 15,000 in training colleges compares with a present 2·7 million students in the United States and an increase to nearly 7 million by 1970, when the university population in Britain is expected to reach 142,000. When all allowance is made for the great variation in standards in American universities, for the high proportion—almost 50 per cent—of students who are unable to complete the course, and for the probability that much of the first year's work in an American university is done in the schools in Britain, the disparity is disturbing. Nor is it less so in regard to postgraduate students: the 10,000 students reading for postgraduate degrees or doctorates based on research in Britain compare with about 250,000 in the United States; and although the percentage of students who are postgraduates is about the same in both countries, there were 2,600 postgraduate students at the Massachusetts Institute of Technology alone, compared with 1,577 postgraduate students of technology in the whole of the United Kingdom.

It would be absurd for Britain to attempt to expand university and technological education on such a scale. The comparison rather emphasizes the importance of seeing that institutions in Britain at all levels are adapted to the tasks they are called upon to undertake, that the utmost care is taken to discover talent, to eliminate waste at the various levels and to ensure that the most effective use is made of trained man-power when it enters industry or other employment. Prof. Lovell in the lecture already mentioned said that unless the West overcomes its present parsimonious attitude to science and technology, the relative quality of our civilization will decline and our influence will pass to other people; and, although he was thinking more particularly of research, that comment applies no less forcibly to education. There, least of all, have we provided the facilities necessary for our existing scientific man-power.

Leaving for the moment the magnitude of expenditure in Britain on education, there is the question of priorities. Unless these are properly determined, and periodically adjusted to changing circumstances and needs, we are unlikely to obtain full value for our expenditure whatever its magnitude. If priorities are rightly chosen and care is taken to see that trained man-power is wisely and efficiently used, Britain's needs will be met with a much smaller total expenditure and one well within her comparatively limited resources, provided the appropriate measures are consistently supported and are not made the playthings of party politics.

That is largely a matter of educating public opinion, and at this point education is linked with the work of such bodies as the British Association. Addressing the annual meeting of the Indian Science Congress in New Delhi on January 22 on the work of the British Association, the Duke of Edinburgh expressed the opinion that one of the three objectives of the Association, namely, to provide for non-specialists an annual stocktaking in intelligible language which would review the progress of science and help to make clear its significance and possible consequences, is more important than ever. Every human invention or discovery can be used, he said,

for good or for evil, and in the end it is the people as a whole who will decide which it is to be. It is therefore essential that the possible consequences of scientific research should be put before the forum of ordinary people. Only in this way can the combined opinion of reasonable, upright and humane men and women throughout the world exert the necessary pressure to ensure that science is used to set free and not to enslave mankind.

That is notably true in respect of education as a whole, and the Duke of Edinburgh's remark earlier in his address, that the Association had become a very useful platform for scientists to express their opinion on Government scientific policy, also applies to educational matters. Besides this important function, the British Association has indeed formed, as part of a wider programme to develop the educational programme for young people, a study group to examine the educational system for scientists.

The determination of priorities, however, is outstandingly a matter of co-operation. In his fifth Fawley Lecture on November 6, 1958, Sir Harry Pilkington, speaking of "Facing the Future in Industry", stressed the need for industry to increase the time given to internal training as well as to external education, to learning and earning at the same time, and referred particularly to the growing demand for informed judgment and consequently higher standards of management and leadership. If full use is to be made of the opportunities which science now presents, time, effort and money must be directed to the right objectives, and he believes that disciplining research effort is essential ; in many industries the glamour attached to research impedes co-ordination between research, technical development and production, and may lead to loss of leadership.

Whether industry is able to work out, as Sir Harry suggests, a constructive code and philosophy of co-operation and then take on a much more positive attitude to combination and co-operation on technical and commercial subjects, and whether it can also hold its own against the growing industrial power of totalitarian countries, depends largely on the talent it is able to attract. That of itself suggests that a first priority in education should be, if not the actual search for talent, at least positive measures to ensure that the chances of talent failing to be encouraged and developed from any cause are kept to a minimum. In a recent article in *European Productivity* (No. 29 ; June 1958) on "Western Europe's Buried Talents", Dr. R. Schairer suggested the formation of a study group of men and women experienced in the promotion of talent, to examine the factors such as talent development, poor teaching methods, shortage of school accommodation and early entry into industry, which are responsible for loss of talent, and to study methods for fostering its development. Dr. Schairer believes that 10 per cent of all funds for educational and scientific development should be earmarked for the search for talent, including the earmarking of scholarship funds for the discovery and promotion of creative talent, especially in the age group 20–50. In this connexion, it may be noted that in a foreword to the recent pamphlet on "Teaching Mathematics in Secondary Schools", Mr. Geoffrey Lloyd said we had clearly reached a stage in which our methods and curriculum need to be considered afresh.

If the discovery of talent is a first priority, and the educational system of Britain should be constructed so as to ensure that, so far as possible, no school-leaver capable of benefiting by a university education should be debarred by lack of means from entering a university, it does not follow that room must be found in the universities for all who seek admission and have obtained the basic qualifications, whatever they may be. Creative talent is not necessarily best developed in a university, and if all real ability is channelled through the universities, the effects on various aspects of national life may well be adverse ; quite apart from whether the nation can afford the necessary expansion in the resources devoted to university education. The expansion of university and technological education has clearly to be planned in some relation to the supply of appropriate talent ; but it should also be in balance with the capacity of the educational system both to supply the supporting technicians and craftsmen needed for efficient use to be made of the most highly trained and creative man-power, and also to ensure that the general body of citizens has a lively appreciation of the issues involved. It is as vitally important to see that the main body of school leavers are adequately educated and able to face the demands of life in an age of rapid technological change, as it is to ensure that the best use is made of the brain-power available.

The recent White Paper on Secondary Education in Britain struck the right note in its emphasis on parity of opportunity, and the development of the educational system so that it can better produce citizens who are fitted by character, knowledge and skill to play their full part in an increasingly educated and responsible democratic society.

QUEEN AND SERVANT OF THE SCIENCES

Teaching Mathematics in Secondary Schools (Ministry of Education Pamphlet No. 36.) Pp. viii + 154. (London : H.M. Stationery Office, 1958.) 6*s*. net.

MUCH has recently been said and written about the claim that mathematics is a language, and in the foreword to this excellent volume (too valuable and too comprehensive to be termed a pamphlet), the Minister of Education himself asserts that the subject must be "taught as a language". Those who have made mathematics their special study will need no convincing that it *has* a grammar, a literature and a poetry. In the years before the Jeffery syllabus, which here receives critical examination and strong support, far too many boys and girls left school having spent a part of every school day working at 'maths' without being allowed (as was Moses) to gain even a glimpse of the Promised Land. In fact, they probably never knew that there was anything worth

working for, anything but 'sums' and (worse still) 'problems'; they had all the drudgery of the driest of the grammar and none of the fun of the literature, much less the poetry. But for one limiting factor (to be mentioned below) this should no longer be the case for any of the teeming multitudes in the secondary schools of Great Britain, and the various chapters in this book set out clearly and enthusiastically why (and to some extent how) this can be accomplished. No authorship is, of course, ascribed to this official publication, but one thing is certain: 'they' have all taught the subject successfully, for only after experiencing the thrill of success with a class could these chapters have been written.

Every library in Britain should have copies of the book on its shelves, if only because it contains a valuable account of the development of mathematical teaching in England (and Wales ?) since the middle of the nineteenth century. A footnote (p. 67) reveals the authorship of the first official publication (Circular 711; 1909), which guided the schools in using the new-found freedom from the "bad parts of the Euclidean tradition". By the saddest coincidence, W. C. Fletcher (1865–1959) died two days before Pamphlet 36, which thus pays tribute to his great work for school mathematics, was published. All teachers of mathematics—not only those who dare to call themselves mathematicians—should read, mark, learn and inwardly digest this new book. In it they will find the encouragement to make themselves better able to teach, and the advice that the reports of the Mathematical Association provide the best means of doing this.

The rest of the volume gives an excellent outline of the present position (Chapter 2) in English secondary schools, goes on to show (Chapter 3) how essential it is to understand what has been done in the primary schools, and Chapter 4 discusses critically much of what is done (and should not be) in many secondary schools, as well as giving much sound advice on what should be done in the next four or five years. These years, which for the majority of boys and girls have no General Certificate of Education or any other examination at the end of them, will contain the only full-time instruction in mathematics these young people will receive. How essential it is, therefore, that the content and the approach (Chapter 6) should be the right one.

Chapter 5 is concerned with the sixth form, and emphasizes the risks we run if pure geometry receives less and less time and attention. Technique in the classroom, including comments on homework and marking (Chapter 8), and the relationship of mathematics to other studies (Chapter 7) are carefully treated, and the importance of an adequate background of the history of mathematics (Chapter 9), so that the teacher may weave a golden thread through all his lessons, is emphasized with appropriate examples.

The limiting factor in all this is, of course, the dire shortage of capable teachers, and without them the high ideals inspired by the report cannot be fully achieved. Yet even here there is cause for hope. "The fear of mathematics is more widespread than it should be", and "girls capable of going far in the subjects are more numerous than is commonly supposed" indicate that it should be possible to inspire a greater interest and facility in many more young people if "a real attempt is made to fit the mathematics to the pupil". Even with the present teaching staff, many of whom are gallantly attempting to teach up to the limit of their own accomplishment, much more can be achieved through the right approach and the best methods. By this means more boys, and especially more girls, may be encouraged to specialize in this subject, and so enable Britain "to remain in the forefront of scientific advance".

W. J. Langford

ATOMIC COMFORTS

On Nuclear Energy

Its Potential for Peacetime Uses. By Donald J. Hughes. Pp. xi+263. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1957.) 30*s*. net.

THIS book represents one of the first attempts to combine an account suitable for the layman of the fundamental physical facts of nuclear energy with a discussion of its national and international implications, in particular of the possibility of development by peaceful international co-operation. In a foreword, Mr. Lewis L. Strauss describes one part of the book as being "one of the most complete and responsible surveys of the subject to appear in print". One fears the worst after this: fortunately, one's worst fears are not quite realized.

But in the chapter entitled "The International Atom"—even though the sub-section in question is headed "International Atomic Energy before Geneva" and the Geneva Conference on the Peaceful Uses of Atomic Energy was held in 1955—nothing is said of the period between 1945 and 1953. The year 1953, the first year of the Republican administration in the United States under President Eisenhower, is treated as the start of the period of international negotiation. Would it have been irresponsible to mention the diplomatic struggle of the first seven or eight years—the first half, indeed, of the atomic age ?

In a later chapter having a sub-section headed "Safety in Bomb Tests", the author takes two-thirds of a page to discuss whether to discuss this matter, then less than three pages to dispose of it. Although the dangers of radioactivé strontium are mentioned (in two paragraphs), leukæmia is not, and no quantitative statement is made—even of the range covered by the (irresponsible ?) estimates of danger.

Perhaps the real difficulty is that all but about a third of this quite short book is devoted to the necessary layman's introduction to nuclear energy, with chapters headed "Fundamentals of Fission and Fusion", "The Chain Reaction", "Atomic Power", "Neutrons from Reactors", "Radioisotopes", and "Fusion". This part is competent, though undistinguished, but it leaves too little space for the rest, the chapters which the now educated layman must study before he can know what are the problems before him.

Dr. Hughes's repetitive and muddy style of American writing reduces further the amount of information which he can convey. To quote a few sentences out of context: "The destructive phases of fission and fusion energy are practically completely involved with their use as military weapons". "It is a matter of statesmanship to assure that man's life shall be enriched and not destroyed by the developments, rather than to halt a branch of research by edict." "It is interesting, however, that in both personal and information security the concept of negative and positive aspects just discussed plays an important role." Such a style makes clear thought

difficult, and it is to be doubted whether the author could have steered us through the really controversial questions in his field. He mentions controversies which have arisen, but a little regretfully. On one question, that of security, he takes a forthright stand, pointing out the danger, even from the strictly national point of view, of too much "negative security".

The book does give a reasonable account of the status of the main national atomic energy projects, and is perhaps at present the best compact source of this information. On the whole, however, I find it too responsible, too comfortable, and too non-controversial. A determined and well-meaning layman who worked through it would scarcely know what all the fuss had been about. G. O. Jones

QUADRUPOLE RESONANCE

Nuclear Quadrupole Resonance Spectroscopy

By T. P. Das and E. L. Hahn. (Solid State Physics: Advances in Research and Applications, Supplement 1.) Pp. ix+223. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 7 dollars.

THE subject-matter of "Nuclear Quadrupole Resonance Spectroscopy" is the resonance phenomenon associated with transitions between states the energies of which depend on the interactions of the nuclear electric quadrupole moment with the field gradient provided by the environment of the nucleus. A small magnetic field may be applied in certain cases and its influence is then treated as a perturbation. The converse case of nuclear magnetic resonance in which the quadrupole effects may occur as a perturbation was dealt with in an earlier volume of this series.

The basic physics of the subject is now well understood and quadrupole resonance thus takes its place as an analytical technique of use both to the solid state physicist and the chemist. This book consists of about 80 pages of theoretical discussion, 10 pages on experimental technique and a little more than 100 pages on applications. The reader is referred elsewhere for a discussion of the fundamental theory, and the account of the applications is not claimed to be exhaustive; but in other respects the book is fairly complete.

One of the practical advantages of quadrupole resonance spectroscopy is that it may be carried out without the use of large and expensive magnets associated with nuclear magnetic resonance experiments. On the other hand, the apparatus employed must be made to tune through a very wide band of frequencies and it is therefore usual to use the damping of what is essentially a super-regenerative receiver as a means of detecting resonance. In such a system it is only necessary to vary one tuned circuit. The descriptions of several satisfactory circuit arrangements have been published and references are given.

The applications discussed in most detail are the determinations of the orientations of molecules in the unit cell and the study of the nature of bonding in various solids.

The work as a whole provides a valuable general introduction to the subject and is likely to be of particular interest to chemists. It is to be regretted that the proof reading was not carried out with more care. R. H. Tredgold

RATIONAL DISCUSSION

The Logic of Scientific Discovery

By Prof. Karl R. Popper. Pp. 480. (London: Hutchinson and Co. (Publishers), Ltd., 1959.) 50s. net.

IT is customary to believe that scientific method has been explained by Bacon and Mill once and for all. Yet science has changed greatly since these two men—who were not scientists—wrote; and so its methods must have changed as well. Einstein, in his Spencer Lecture given at Oxford in 1933, was the first to point out this change. We do not gain knowledge by reading 'the book of Nature' or by following 'a principle of induction'. We start, instead, by inventing a hypothesis and then proceed to test it by its consequences.

This hypothetical-deductive method was developed in detail by Prof. Karl Popper in the German version of the present book, "Logik der Forschung", published in Vienna in 1934. Pre-war conditions prevented the book from being easily accessible in the English-speaking world. Nevertheless, its ideas infiltrated, so that to-day there exists scarcely a philosopher or scientist who does not reject 'inductivism' and accept the hypothetical-deductive method.

The crucial experiment, according to Popper, is the means by which we decide whether or not to accept a hypothesis or theory. In such an experiment, like Michelson's, we try to falsify a hypothesis. If the outcome is positive, that is, if the singular statements derived from it have not been falsified, the hypothesis has withstood the test and is accepted. A hypothesis is never conclusively verified, for it is usually a universal statement; and no finite series of tests could ever establish its truth or falsity. Such a statement, however, is logically equivalent to a negative existential one, and this can be overthrown by a single experiment. Thus a hypothesis 'proves its mettle' or a theory is 'corroborated'. 'Confirmation', which is the common term describing this situation, is rejected by the author, for it suggests that we can firmly establish a hypothesis; and this is never so in science.

Another reason for rejecting induction is that it does not provide a criterion which would allow us to separate science from empty speculation or physics from metaphysics. This is, indeed, a basic problem, well known from the history of science: many attempts have been made to solve it. Physicists usually speak in this connexion of 'meaning'. Factual statements are meaningful if they can be tested by experiment, at least in principle. For example, statements referring to the simultaneous and exact values of position and momentum of a particle are meaningless in quantum mechanics, since they are ruled out by the uncertainty relations. Prof. Popper altogether rejects a criterion of meaning and replaces it by one of demarcation that is agreed upon by convention and "ultimately a matter of decision, going beyond rational argument". Indeed, what we accept as factual or real changes with the progress of science and is not decided by words; but a criterion of meaning could, in my view, do this job as well.

The more falsifiable a hypothesis is, the more it forbids, the more does it say about the world. This is the well-known inverse relation between logical range and factual content of a statement. The hypothesis which is falsifiable in a higher degree can also be corroborated better; and this depends less on the number of favourable instances than on the severity

of the tests the hypothesis had undergone. The degree of falsifiability is complementary to logical probability which, however, must not be confused with numerical probability as we know it from statistics. According to Prof. Popper, statistics cannot help us in corroborating a hypothesis. His views on probability are highly controversial and, I fear, will not be readily shared by practising scientists.

The original text has been enlarged by footnotes and appendixes which make up more than one-third of the book. These additions do not help the book, not only because they are difficult to read, but because they are unduly polemical. A larger criticism is that physics is the only science talked about by the author. However, the rational discussion of its concepts—which Prof. Popper regards as "the one method of philosophy"—results in laying the ghost of induction, and this is the outstanding merit of the book.

E. H. HUTTEN

NATURAL HISTORY OF BRITISH SPIDERS

The World of Spiders

By Dr. W. S. Bristowe. (The New Naturalist: a Survey of British Natural History.) Pp. xiii+304+36 plates. (London: William Collins, Sons and Co., Ltd., 1958.) 30*s*. net.

ALTHOUGH an extremely widespread invertebrate group, spiders have for long been avoided by most British naturalists, amateur and professional. The reasons are probably straightforward: spiders have no æsthetic appeal to the amateur, as have, for example, Lepidoptera, beetles and dragonflies, while the professional has always regarded their biological importance as very low. None of the British species can be regarded as pests in any way, and although they must rank as one of the most important invertebrate predators, their choice of prey is to a great extent non-selective and no means have been found of using their activities to regulate harmful insects or in other ways. Until recently, their interest to the biologist has largely been academic, and the great names in the history of British araneology have been almost all taxonomists. To Dr. Bristowe must go the credit of rediscovering spiders for naturalists in Great Britain, not as lifeless pickled specimens, but as living creatures with activities and behaviour patterns of incredible diversity and quite as fascinating as any other invertebrate group. This book has an unrivalled wealth of personal observations on a great many different species of spiders, both captive and in the field, all of which have been made in his spare time during a busy professional life.

The first two chapters deal with two subjects which are characteristic of Dr. Bristowe's wide interest; spiders in literature and superstition, and what might be called a natural history of British araneologists. Together they form an excellent introduction to the main part of the book and will appeal to all naturalists whether they have a knowledge of spiders or not. Chapters 3 and 4 deal with structure, classification, and the fossil record. Chapter 5 touches all too briefly on the subject of population densities of spiders, and the influence of these numbers on other invertebrates. The next fifteen chapters describe and discuss the biology and behaviour of selected species of all the spider families represented in Great Britain.

While the character of the individual spiders is vividly portrayed by Dr. Bristowe, a less clear picture emerges of the ecology of spider communities. The book is, of course, concerned with the British fauna, but as studies on spider ecology are all very recent and include so much original work and new discoveries, some account of them would have helped to complete the picture. No reference is made, for example, to the excellent studies by Nørgaard in Denmark on the ecology of the *Pirata* species, of *Theridion saxatile* and *Lithyphantes albomaculatus*, all represented in Britain, nor to the population studies in Germany by Bochmann and Knülle on salt-marsh spiders, and by Tretzel and others on terrestrial habitats. A wide new field has developed on this subject during the past twelve years which shows excellent promise of narrowing the gap between our knowledge of spider ecology and that of better-known invertebrate groups.

There is a final chapter on collecting spiders, an up-to-date species list as an appendix, and a short bibliography.

One of the most impressive features of the book is the really excellent series of 332 drawings in line and wash by Arthur Smith. These were specially made for the book and immediately places this volume of the "New Naturalist" books in the front rank of the series for accurate and beautiful illustrations. Dr. Bristowe writes as an enthusiast in a fluent and very readable style. It will be no surprise if this book results in many converts to the study of spiders.

ERIC DUFFEY

CARBOHYDRATES COMPLETE

The Carbohydrates

Chemistry, Biochemistry, Physiology. Edited by Ward Pigman. Pp. xvii+902. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 20 dollars.

FOR some years the Pigman-Goepp book on the "Chemistry of the Carbohydrates" has been the main reference book for carbohydrate chemistry. The book now under review is a complete revision with a considerable expansion of the earlier Pigman-Goepp. For this compilation the editor, Ward Pigman, has brought in no less than twenty specialists in the field to assist him. They have succeeded in adding two new chapters in addition to re-writing and bringing up to date all the previous chapters in the "Chemistry of the Carbohydrates". The vast increase in the volume of publications on carbohydrates is illustrated by the claim of the editor that references are given to no less than 4,500 individual articles. At first glance the book looks like a 'big brother' of any one of the current volumes of the "Advances in Carbohydrate Chemistry" published by the same press, but on closer inspection it is quite clear that much more detail has gone into the new individual chapters. These serve to make the book an excellent reference book which can be used in conjunction not only with the "Advances" but also with the older edition, which does contain some material eliminated from the present book.

The first three chapters, "Structure and Stereochemistry of the Monosaccharides", by Ward Pigman, "Occurrence, Properties, and Synthesis of the Monosaccharides", by John Sowden, and "Esters", by A. Thompson and M. L. Wolfrom, follow the conven-

tional lines of the first book; they are, however, much more comprehensive and are now well developed, and references are given in an exhaustive fashion. The chapter on "Glycosides, Simple Acetals, and Thioacetals", written by *M. L. Wolfrom* and *A. Thompson*, again contains much of the material of the older edition, but gives a better account of the reactions of carbohydrates with aldehydes and ketones: this treatment is excellent. "Polyols, Alditols and Glucitols", written by *R. L. Lohmar, jun.*, represents an extension of previous work and gives a most interesting account of this expanding class of sugar derivative. In addition, the related inositols come in for up-to-date treatment and the whole chapter is important and timely.

Another extension is the discussion of acids and oxidation products by John W. Green, where aldonic acids, aldaric acids, uronic acids, ascorbic acids, and so on are treated together. Most important, the section on oxidative reagents which are of special application in carbohydrate chemistry has been extended.

Ethers, anhydro-sugars and unsaturated derivatives are dealt with in some detail in a clear-cut manner by John C. Snowdon. A very welcome account, since the subject is growing rapidly every day, is that on nitrogenous derivatives written by Ward Pigman with specialist collaborators. The rapid growth of this subject is clearly demonstrated by the fact that no less than seventy pages are devoted to the different aspects of the sugars containing nitrogen. Another almost equally long chapter is that on oligosaccharides, carefully written by W. Z. Hassid and C. E. Ballou. The reader is brought up to date on enzymic synthesis of oligosaccharides in this chapter and modern advances in enzymic studies in this field are well illustrated.

An important and well-written chapter is that on the identification and quantitative determination of carbohydrates by Ray Noggle, though this could well have been placed at the beginning of the book. It is interesting because it includes some work on isotope procedure, including the synthesis and degradation of labelled sugars. The chapter on polysaccharides has been sub-divided into phyto- and microbial polysaccharides and animal polysaccharides. It has been cut down somewhat from the earlier publication and is perhaps the least praiseworthy in the book. This is because there has been a great attempt to put *multum in parvo*, so that a catalogue is now provided which, although it may serve to whet the appetite, appears to be somewhat stilted in the way it is written.

An attempt to introduce yet another classification of the animal polysaccharides with new terms adds but little to an already confused nomenclature. However, the account is well provided with references and will be important from the library point of view.

An excellent chapter on the photosynthesis and metabolism of carbohydrates is produced by Ray Noggle. This is very important and it well illustrates the rapid development in this particular field in the past few years.

Finally, there is a chapter on "The Carbohydrates in Nutrition", by Harry G. Day and Ward Pigman. This is most interesting, it is well written, and adds in more ways than one yet another chapter to the story of our carbohydrate chemistry.

Taken as a whole the book is an excellent one. It will be consulted by chemists, biochemists (academic and industrial), by medicals, and all students of chemistry. An enormous amount of effort has undoubtedly gone into the book and Ward Pigman is to be heartily congratulated on his efforts.

There are very few typographical errors and the style, well known in the "Advances in Carbohydrate Chemistry", is very acceptable. An important fact is that the modern Anglo-American carbohydrate nomenclature has been used throughout.

M. Stacey

ABORIGINAL ART

The Tiwi

Their Art, Myth and Ceremony. By Charles P. Mountford. Pp. 185+64 plates. (London: Phoenix House; Melbourne: Georgian House, 1958.) 65*s*. net.

The aboriginal art of Arnhemland in Northern Australia is particularly rich in the variety of its forms, technical control and harmony of colour and design. Tools and materials are of the simplest; cave walls, bark, wood and cane; black pigment, red, yellow and white ochres; brushes made from bark; and fixatives derived from the sap of tree orchids or from a mixture of wax and honey. Most men can paint and carve but some are more skilled than others and acquire a reputation within their region. Nevertheless, all work within the same tradition, and no premium is placed on individuality and innovation.

We already have two monographs dealing with art in Arnhemland, one by Mountford (1956), and an earlier one in colour by Elkin and Berndt (1950). The present volume is concerned with the art of Melville Island, 14 miles to the west, where a distinctive style has been developed in the treatment of figured bark paintings, carved and painted burial poles, decorated bark baskets and ceremonial spears. As elsewhere in Australia, most of these objects are produced for a ceremony, and their value is of an especially sacred character in so far as they form an integral part of the rite, and portray in geometrical and naturalistic figures the supernatural beings and events occurring in myths. Mountford makes the point that Tiwi art is more highly formalized than that of the east and cannot be interpreted without the aid of the artist. The interpretations of the paintings reproduced in black-and-white in this book are recorded by Mountford; what he does not tell us is how far similar interpretations were or would have been offered by other adult men in the community. Nevertheless, it is valuable to have at least the artist's point of view; and this, along with the superb photographs, make the book a useful contribution to studies of aboriginal art.

From the anthropologist's point of view the book is disappointing in that both title and publisher's note are misleading. Mountford does not give us an analysis of all Tiwi myth and ceremonial, but confines himself to a description of the ceremonies of mourning and initiation witnessed by him and the myths associated with them. He omits to give an outline of the social organization, though a knowledge of this is essential for a full understanding of myth and ritual. He himself, as leader of the expedition, had little time for research, but he might have made use of material already published by field-workers and listed by him in his bibliography.

Phyllis Kaberry

La Disputa Leibniz-Newton sull'Analisi

(*Enciclopedia di Autori Classici*, 2.) Pp. 239. (Torino: Editore Paolo Boringhieri, 1958.) 1,200 lire.

THIS valuable little book contains the principal documents in the Newton–Leibniz controversy over the invention of the infinitesimal calculus, translated into Italian and briefly annotated by Dr. G. Cantelli. Of these, the most important is the long review (generally held to be by Newton himself) from the *Philosophical Transactions* of 1715, which sums up carefully, but decisively, in the author's favour. To present-day readers, however, the most interesting things in it are the incidentals. Thus Newton claims that his method of fluxions is more rigorous than Leibniz's theory of differentials, since "we can form no idea of infinitely small quantities". Again, Newton admits that the majority of the results in the "Principia" were obtained by his new analysis and only afterwards clothed in geometrical form. Finally, he goes beyond the limits of the controversy to attack his rival's natural philosophy. Between Newton and Leibniz lies "an enormous difference": the first proceeds only so far as experimental evidence leads and then stops, while the second is a slave to hypotheses which he blindly believes as eternal truths.

On the other side of the dispute Leibniz, from modest beginnings and courteous exchanges, gradually raises the stakes as his honesty and good faith are increasingly questioned by Newton's friends. Expressions of admiration for Newton's genius give place to complaints and accusations; the claim to independent discovery becomes an assertion of priority. Then his supporter, John Bernoulli, plays his trump card: if Newton had in fact discovered the calculus earlier, why did he not use it in the "Principia", which offered so many opportunities for its application? Instead, there is not a trace of analysis in the whole work. . . .

What are the rights and wrongs of the quarrel? The editor confesses that he is at a loss to say. It would be safer to maintain, with Wallis, a neutral position and ascribe the invention of the calculus to neither party but to the pioneers, above all to Cavalieri and Newton's own teacher Barrow.

L. ROTH

Systematic and Experimental Studies on Protozoal Blood Parasites of Egyptian Birds

By Dr. A. H. Helmy Mohammed. Vol. 1: Pp. xi+166 (plates 1–6). Vol. 2: Pp. ii+167–298 (plates 7–13). (Cairo: Cairo University Press, 1958.) n.p.

THE book is the outcome of a survey, for protozoal parasites, of birds collected, near Cairo, over two complementary halves of two years, during which time some 885 birds were examined. It is, then, a report on the personal research of the author and serves, not as a general text-book but as a useful reference book for the limited few working in similar fields. Of necessity it varies in the accuracy of the incidence figures according to the methods of examination and to the numbers of a host species examined, and, in common with other works of this kind, does not claim to be complete.

The first section is devoted to speculations on the meaning of the figures for incidence listed early in the report; some are based on evidence too scanty to be of any practical importance; others, for example the use of evidence on distribution of the parasites to hint at the identities of their vectors, may be used profitably by future workers. This is followed by three sections dealing in turn with the species of Piroplasms, *Plasmodium* and *Haemoproteus*, found in the survey, together with reviews of the systematic problems surrounding these parasites. Dr. Mohammed includes sufficient information to clarify the problems in hand without attempting general reviews. The last section is an account of the development of *Haemoproteus columbae* in the pigeon fly, *Pseudolynchia canariensis*, a confirmation and extension of the work of H. Adie in 1915.

ELIZABETH U. CANNING

A Guide to Field Biology

By *John Sankey*. Pp. xvi+166. (London and New York: Longmans, Green and Co., Ltd., 1958.) 12*s*. 6*d*. net.

IT is particularly appropriate that the author of this admirable little book should be a warden at one of the centres of the Field Studies Council, which has played a notable and pioneer part in encouraging field biology in secondary schools in Britain. As might be expected of one with ten years experience in this type of teaching, Mr. Sankey's account is lively and practical in outlook. Ecology is a subject which is not easy to teach or to write about. The simple and straightforward approach adopted in this book should go far towards dispelling any doubts, still often voiced in educational circles, that field-work is too complex to be undertaken profitably without elaborate apparatus and a disproportionate expenditure of time. Guidance is given on how to study particular kinds of plant and animal habitats and there are useful sections dealing with such aspects as the planning of projects, also methods of collecting and identification.

W. H. DOWDESWELL

Venture to the Arctic

Edited by R. A. Hamilton. (Pelican Book No. A432.) Pp. 283+32 plates. (Harmondsworth, Mddx.: Penguin Books, Ltd., 1958.) 5*s*.

THIS book performs a new and very welcome function in the sphere of expedition literature. It tells, in terms of popular science, the story of the British North Greenland Expedition of 1952–54. The main narrative of any expedition, normally written by the leader, cannot find room for more than a few pages on this, and anyway, is almost always written before the results are known; and the results themselves are both too technical and scattered over a wide range of journals. This book is directed to the 'man in the street', who is entitled to hear about what he has helped to pay for. He will find it of fascinating interest, and his idea of what a modern scientific expedition accomplishes will probably be considerably extended. But although it is designed for the non-specialist, the contributors have rightly understood that popularization implies simplification of language rather than of ideas, so that the specialist will also gain from reading it. R. A. Hamilton, as chief scientist, fills in the background of planning and organization, and contributes his own meteorological results, besides editing the whole. F. R. Brooke describes the survey, C. B. B. Bull the seismic sounding and gravity work, J. P. Masterton and H. E. Lewis the medical and physiological aspects, H. Lister the glaciology, J. D. Peacock the geology and P. J. Wyllie the geomorphology. It is much to be hoped that other expeditions will follow this lead. They could have no better example before them.

T. E. ARMSTRONG

THE ZOOLOGICAL SOCIETY OF LONDON

By Sir SOLLY ZUCKERMAN, C.B., F.R.S.
Secretary, Zoological Society of London

OVER the past eighteen months the affairs of the Zoological Society of London have attracted considerable attention in the national Press, first because of a proposal to alter the Society's by-laws, and more recently through the publication of plans for the reconstruction of the Regent's Park Gardens. Alterations in the Society's by-laws can be proposed only by the Council; but the constitution demands that they have to be endorsed by the body of Fellows. The 1958 proposals, one of the main objects of which was the strengthening of the scientific and educational activities which are the sole purpose for which the Society was incorporated by Royal Charter in 1829, were accepted by well over half the 3,000 Fellows who took the trouble to vote. One of the dissenting minority decided to challenge the Council on the construction of the by-law defining a majority, his argument being that in order to validate any proposal about by-laws it was necessary to obtain an absolute majority of the 7,000 or so Fellows in the Society, whether or not they voted. This view was upheld in the Chancery Division on December 5, 1958, but reversed in the Court of Appeal on March 20, 1959.

To see this affair in perspective, it is useful to consider the past history of the Society; its future plans; and the purpose of the 1958 changes in the by-laws, which have now become effective.

History of the Society

The Society was founded by Sir Stamford Raffles and Sir Humphry Davy, then president of the Royal Society, "for the general advancement of zoological science". As an immediate object it was hoped to collect in London "such living species of the animal kingdom as may be introduced and domesticated with advantage in this country". It was also suggested that the Society should found both a zoological museum and "a Library of all Books connected with the subject". The first problem was to find the money necessary to realize these objects, as well as the authority to establish a menagerie on Crown land in Regent's Park. Almost inevitably the Fellowship became a combination of professional zoologists, and of subscribers who ranged from amateurs with a deep specialist knowledge of a particular part of zoology, to persons to whom membership was little more than a means either of granting patronage or, in some cases, of gaining prestige or privilege. There was no alternative to this development if the resources were to be found.

After considerable negotiation with the Government, a lease of five acres of Regent's Park was granted in 1826, which was soon increased to about thirty acres. Within ten years there were 3,000 Fellows, and for the first twenty years or so entrance was restricted to them and their friends, since they, in effect, were the patrons whose contributions had made the venture possible. Their number then started to decline, and in 1847 it was decided to admit the public by payment at the gates. The reason for this departure was essentially financial, even though the Council of the day was authorized to express the Crown's approval of the step as a measure which helped to diffuse "intellectual recreation among the great mass of the people". The decision brought an immediate improvement in the Society's fortunes. Within three years total revenue had all but doubled, and Fellows' contributions fell to about 40 per cent of a budget of about £15,000. In 1900 incomings were about £29,000, to which Fellows contributed about 38 per cent. By 1938 the proportion had fallen to 16 per cent, and to-day it is only about 5 per cent of the half-million pounds a year now needed to administer the collections of animals in Regent's Park and in Whipsnade Park, nr. Dunstable, Beds, and the Society's many other activities.

The spark which touched-off the recent dispute in the Society's affairs was a decision by the Council to open the Regent's Park Gardens to the public on Sunday mornings, which *ipso facto* meant the withdrawal of a privilege of restricted entry which was highly valued by some Fellows. One of the main reasons for this decision was the Society's urgent need for funds to meet rising costs and to start a major rebuilding programme. Sunday afternoons, which had been 'public' since 1940, already provided through gate receipts relatively more to the Society's revenues than the takings of any full day of the week. Additional receipts on Sunday mornings over this past year have practically equalled the total net revenue received from Fellows. The question of rates was the second main reason for the decision to open the Gardens. The Council had been advised that only a substantial increase in the amount of voluntary subscriptions, and a decline in the proportion of the subscriptions from which the Fellows derived a personal benefit, would make it possible for the Society to qualify for exemption from liability to rates as a scientific society under the Scientific Societies Act of 1843. The withdrawal of the privilege of exclusive entry on Sunday mornings has already materially altered the situation.

The uproar this occasioned did not come from the hard core of professional zoologists who are members of the Society. For many years there appears to have been an attitude within the administration of the Society that all subscriptions to its coffers were to be welcomed, whatever their source. As a result, the Fellowship of the Society has at times risen to as many as 8,000, and it is not surprising, therefore, that some of those who became Fellows were unaware of the fact that the existence of the Zoological Society as an institution under a Royal Charter depended solely on the fulfilment of the object for which it was founded—namely, the advancement of zoology and animal physiology. Attitudes resulting from a confused interpretation of this purpose are undoubtedly to blame for some serious public misunderstandings about the nature of the Fellowship.

Scientific Activities of the Society

But however prevalent the misunderstanding, the Society has at no time failed to discharge the obligations of its charter. The Library which was

started in 1835 is now one of the finest collections of zoological literature in the world. A Museum begun even earlier provided a valuable part of the early collections of the British Museum (Natural History). Regular scientific meetings have been held uninterruptedly ever since 1827, the Society taking over from the Zoological Club of the Linnean Society, which was then dissolved, as a national forum for zoological discussion. The leading zoologists of Britain have always contributed to these meetings, some of which, for example the famous meeting which in 1919 considered the phylogenetic and taxonomic status of *Tarsius*, are part of the general history of zoological science. The *Proceedings* of the Society, which now appears eight times a year, began in 1830, and the first part of the *Transactions* of the Society appeared in 1833. Both have been issued uninterruptedly ever since. Since 1886, the Society has also been responsible, for a time in association with the Royal Society, for the publication of the "Zoological Record", which had been started in 1864 by a group of zoologists connected with the British Museum.

In addition to this normal pattern of discussion and publication, which applies to all scientific societies, the Zoological Society has always been somewhat more directly concerned with the advance of zoology both through the work of its officials, and through the provision of anatomical and pathological material to research workers in other institutions. This contribution appeared more conspicuous in the nineteenth and earlier part of the present century, when the total volume of zoological research was far less than it is to-day, and when its emphasis was largely morphological and taxonomic. With the recent establishment of a new Veterinary Hospital and Pathology Department, the standards of animal husbandry in the Society's menageries, as measured by the decline in mortality-rates and an increase in birth-rates, are now improving fast. To-day both indices stand at record levels in the Society's history. The provision of new laboratory facilities will undoubtedly strengthen the direct part which the Society can play in the future advance of zoological science.

Educational Activities of the Society

These activities represent one of the two ways in which the Society discharges its obligation to advance the science of zoology. The other is the encouragement of zoological education, primarily, of course, through the maintenance of animal collections which, excluding fish and invertebrates, to-day constitute nearly 1,200 species or subspecies. The Society's menageries provide a far better picture of the range of the animal kingdom than, so far as is known, any other zoological collection in the world.

In co-operation with the educational authorities of the Greater London area, and with the help of the Nuffield Foundation, the Council, two years ago, established regular courses for school-children up to and including the sixth form. These have proved very popular, and a number of schools are now including the lecture-demonstrations as a normal part of their teaching time-table. In the previous year, the Society had established, jointly with the Granada T.V. Network, a full-time Television and Film Unit, the main effort of which now is the preparation of a series of films representing different aspects of animal life. This venture should add greatly to the Society's educational potential, as will also a Young Zoologists Club, founded early this year, and which has already attracted more than 1,300 members.

New Subscription Rates

The Council is confident that the reform in the structure of the Society made possible by the new by-laws will not only lead to an increase in the net revenue from Fellows, but will also powerfully reinforce the scientific strength of the Fellowship. Until this year the subscription of a Fellow had remained unchanged at £3 for well over one hundred years, and was incommensurately low in relation to privileges which potentially could be demanded in return. But unlike what prevails in almost every other scientific society, a Fellow did not obtain the published *Proceedings* of the Society as of right. Many professional zoologists who were unable to attend meetings, and who were uninterested in other rights of subscribers, could scarcely, therefore, see how membership helped develop their own science. Equally, they found it difficult to see how in such circumstances they could assist the Society in achieving its purpose. Raising the subscription of Ordinary Fellows to a realistic level had, therefore, to be reconciled with the certainty that very few scientists or teachers would belong to the Society at all if their subscription was not kept within the normal range of other scientific bodies. The 1958 by-laws have achieved the necessary compromise. Scientific Fellows now subscribe £4 and receive the *Proceedings*; while Ordinary (non-professional) Fellows subscribe £8 a year, without receiving the Society's scientific publications. Non-voting Associates continue to pay the old 1832 subscription of £3. While not deterring non-professional patrons of zoology, these changes will, it is anticipated, lead to a powerful recruitment of professional research workers and teachers of zoology.

Building Plans

By coincidence, the decision of the Appeal Court that these changes in the structure of the Fellowship had been validly confirmed by the Society was announced almost simultaneously with the publication of plans for the rebuilding and re-landscaping of the Regent's Park Gardens. The main purpose of the new plans, which have been devised by Sir Hugh Casson and Mr. F. A. Stengelhofen, is threefold. First, they provide modern accommodation for the animals; secondly, they improve public amenities and facilitate the circulation of visitors; and thirdly, they improve the Zoo æsthetically, by a more spacious and yet cohesive lay-out. The pre-requisite of a flexible master-plan was the need to achieve an initial degree of mobility by clearing at least one big site in an already overcrowded area. This will be accomplished in about a year's time, when the building of a new Works and Supplies Department, which is now being erected, is completed. The area at present being occupied by the Works Department will then be developed as paddocks for deer and antelopes, and the present quarters of these animals will in turn be adapted for elephants. From then on the plan should unfold smoothly.

The first step in planning was, of course, to define a general policy about animal collections. The decision was that a zoo in the metropolis should avoid expensive duplication and should contain, for

educational purposes, as representative a series of the more important types of animal as can be got together. The aim, therefore, is to have in Regent's Park a collection the value of which is measured not by the number of its individual exhibits, but by the extent to which it represents the animal kingdom. In achieving this policy, the Society has the enormous advantage that since 1931 it has also owned Whipsnade Park, which covers more than 500 acres, and where the Society can help play a part in projects of animal conservation, such, for example, as keeping in existence species (for example, the Père David deer) that have already disappeared in the wild.

While these and other basic considerations were in process of decision, detailed consultations were started with the Ministry of Works and the Commissioners of the Crown Estate, who are the Society's landlords in Regent's Park. The new plan not only has their general approval, but also that of the London County Council and the Royal Fine Arts Commission. The larger part of the Zoo is on the south side of the Outer Circle. The main gate by which it is entered is being moved in such a way that the visitor of to-morrow will see down broad steps into a 'square' from which he can look around the Zoo and also into the Park beyond. At the same time, the Zoo and the Park will be landscaped so that their natural features are continuous on either side of a water-barrier which will mark the boundary between the two. Within the Zoo different areas will have distinctive characters, and will be connected by elevated walkways. The north gate will be moved to a more central position near a new bridge, and the banks of the canal, which separate the north from the middle garden, will be used, wherever possible, as grazing paddocks. The scientific and educational buildings will also be increased in size.

Fortunately, the first three years of rebuilding can be paid for out of funds which accumulated during the post-war period, when building restrictions made it impossible to carry out any reconstruction, and when large crowds visited the Regent's Park Gardens partly because of restrictions on motoring, and partly because of the relative lack of other public attractions. But in due course new sources of revenue will have to be found. The Society does not get any subsidy from public funds, except indirectly, in so far as the rent it pays for the Crown land it occupies has not increased for more than a hundred years. Almost every other big national or civic zoo in the world is subsidized. For example, the New York Zoo receives annually from the New York municipal authorities a sum that almost equals the total revenue which the Zoological Society of London has to earn. Other American zoos are also supported by their city governments. Most of the German zoos are municipal zoos which were reconstructed after the War out of public money. The Paris zoo depends for support on the Ministry of Education. The complete fulfilment of the plan for the Regent's Park Gardens will almost certainly need sources of revenue additional to that provided by the public at the gates.

Wherever the money comes from, the present plan of rebuilding is not some visionary scheme for an undefined future. It is a programme of redevelopment that is already being pursued. It is a plan, too, the implementation of which coincides with the first major change that has been made in the structure of the Fellowship since the Society's foundation 130 years ago. This change re-emphasizes the scientific and educational purpose for which the Society exists. In 1841, when the Regent's Park Gardens were managed largely as a private venture for private enjoyment, the following resolution was passed at a general meeting by an overwhelming majority: "The Society cannot divest itself of the scientific character so essential to its dignity and respectability without violating the Charter of Incorporation". The sense of this resolution is far truer to-day, when the management of the Society constitutes a trust that can be vested only in those who have the necessary knowledge to discharge the scientific and educational purposes of the Charter, and also the official or business standing commensurate with the responsibilities which the Society carries on behalf of the public.

SHOREWARDS UPSLOPE OF THE LAYER OF MINIMUM OXYGEN OFF BOMBAY: ITS INFLUENCE ON MARINE BIOLOGY, ESPECIALLY FISHERIES

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Earlier Knowledge of Upwelling in the Arabian Sea

THERE are two factors of particularly great interest in the Arabian Sea: the seasonal upwelling caused by the prevailing monsoons and their changes, and the well-developed tropical subsurface layer of minimum oxygen. Both have pronounced effects on marine biology and especially on the seasonal nature of the local fisheries.

Upwellings along the Somali and South Arabian coasts and also around the southern tip of Ceylon during the south-west monsoon were indicated by Schott[1] on the basis of low surface temperatures then prevailing there. Upwelling could be expected to exist along the Bombay continental shelf during the north-east monsoon, and Jayaraman and Gogate[2] have earlier found indications which probably attest such between 20° and 22° N. latitude along this

coast. Their conclusion was also based on the distribution of temperature and salinity there.

Layer of Minimum Oxygen

The tropical subsurface layer of minimum oxygen in the Arabian Sea has been described in reports devoted to the *John Murray* expedition of 1933–34. Of all tropical seas the layer of minimum oxygen is most pronounced in the Arabian Sea, where the oxygen content is nearly nil at its mid-depth. The upper boundary of the layer is relatively sharp and coincides with the sharp thermocline or is slightly below it. The depth of the thermocline varies seasonally, dependent upon the seasonal upwelling or the coastal piling-up of the surface waters according to the prevailing monsoon. According to Schott[1], the layer of minimum oxygen is most pronounced off Bombay, where it is found generally at the depth of 50 metres.

Most usually it is found in the northern part of the Arabian Sea at the depth of 75 metres, but towards the equator it descends to reach a depth of about 150 metres. Salinity within the layer is relatively high, being in the north around 36 per mille and in the central Arabian Sea about 35·5 per mille with temperature at 22–23° C. It is noteworthy that the salinity maximum is found slightly below the layer of minimum oxygen. Gilson[3] found a high nitrite content in the layer of minimum oxygen, and immediately above it a high concentration of plankton was recorded.

The layer in question cannot fail to have a pronounced effect on marine life. It is to be expected that where it runs into the contour of the continental shelf, very little if any animal life will be possible beneath. Furthermore, in the event of upwelling raising the layer of minimum oxygen, animal life in the water above will be endangered. Proof of this has been recorded on several occasions. There is an area in the southern part of the Arabian Sea, between long. 60–65° E. and lat. 6–12° N., where mass mortalities of pelagic fish have often been reported during the month of June. This area being a divergence area of winds and of the drift currents caused by them (it is actually the centre of a gyral), upwelling of the layer of minimum oxygen there is to be expected. Mass mortality of fish has also been reported along the Arabian and Indian coasts in areas and seasons where and when upwelling of the layer is to be expected. Such mass mortalities might very well be caused by the upwelling of the layer of minimum oxygen alone or in conjunction with the accompanying 'red tides'.

Investigations off Bombay during October–November 1958

Some modest investigations were made off Bombay during the latter part of October and the beginning of November 1958 by the personnel of a refresher course in marine biology sponsored by the United Nations Educational, Scientific and Cultural Organization. Because the north-east monsoon starts in October, an accompanying upwelling of the layer of minimum oxygen along this coast should be expected then because of the direction of the wind. This was in fact found, the layer with an average oxygen content of 0·7 ml./l. occurring at an average depth of about 18 m. some 18 nautical miles out from the coast. The slope of the discontinuity layer was upwards towards the coast (Figs. 1–3). The salinity

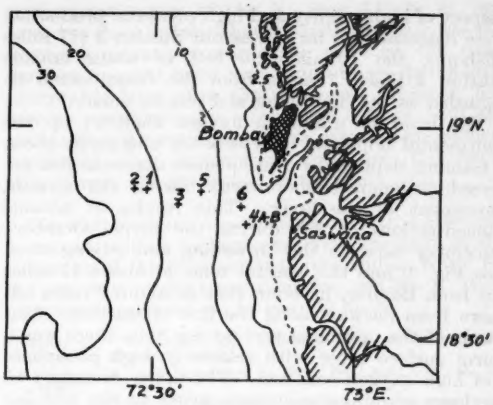

Fig. 1. Depth contours (in fathoms) and position of stations off Bombay

in this layer of minimum oxygen was about 36·0 per mille and the temperature around 24° C. The phosphate content was also relatively high (greater than 1 μgm. at./litre). In a zone 7–10 nautical miles from the coast, the layer of minimum oxygen practically reached the surface. The oxygen content there was very low from surface to bottom (see Station 4). An intensive mixing by tides takes place in this zone, where the water was found to be rather turbid. Inshore of it there was coastal water which was also thoroughly mixed by the tides and which contained higher amounts of oxygen. This coastal water was extremely muddy because of the intensive tidal mixing and the soft nature of the bottom. Pronounced colour changes were noticed in the water. Near the coast it was brownish grey out to about 7 miles offshore. Seawards of this for some 3 miles the hue was greenish-grey. Still farther out the colour of the water graded into blue. Because the effects of the upwelling in

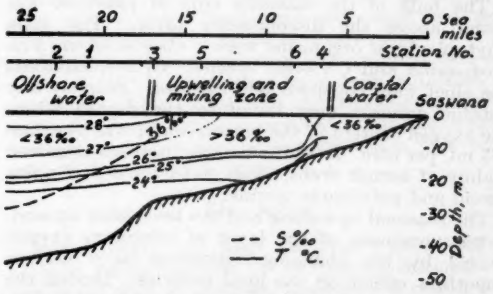

Fig. 2. Distribution of temperature and salinity off Bombay (beginning of November 1958)

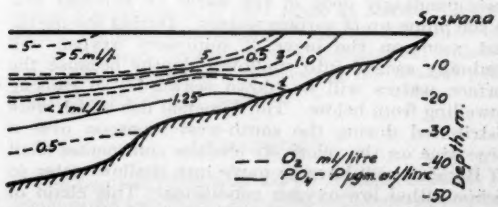

Fig. 3. Distribution of dissolved oxygen (ml./l.) and phosphate phosphorus (μgm. at./l.) off Bombay (beginning of November 1958)

respect of high salinity and high plankton production were detectable as far out as our Station 3 (17 miles offshore), the 10-mile-wide belt of water outside Station 4 (itself 7 miles from the coast) could be regarded as the 'upwelling and mixing zone'.

The layer of minimum oxygen shallows up the continental slope and intersects the bottom at about 7 fathoms depth. In consequence, demersal fish are forced to migrate shorewards during the upward movement of the layer. This results in notable concentrations of fish during the period October–December between the 'upwelling and mixing zone' (see Fig. 2) and the 'coastal zone' at about 13 miles out from Bombay harbour, that is, about 7 miles offshore from Saswan along the line of stations. Seawards of the upwelling and mixing zone there was a warm surface layer with relatively high phosphate and high oxygen contents. The upper boundary of the layer of minimum oxygen seems to rise and fall with the tides (see the observations from Stations 4*A* and 4*B* in the accompanying tables). This can be expected to cause up-and-down migrations of the fish concentrated in the area where the layer of minimum oxygen intersects the bottom contour. These vertical fish movements are known to the local bag-net fishermen. An abundant growth of plankton was found in the 'upwelling and mixing zone' which is likely to exhaust the nutrients from the surface layer rather quickly, and in fact a decreasing phosphate content was found going offshore. Also the oxygen content of the upper surface water showed a decrease farther offshore, which might be ascribed to the consumption of oxygen due to the decomposition of the organic matter produced in the upwelling and mixing zone and in its vicinity. Both the decrease of nutrient content in the surface layer and the downwards sloping of the thermocline and layer of minimum oxygen will probably continue as one goes farther offshore. Gilson[3] found in December and January off Bombay (at the edge of the continental slope) that the thickness of the surface layer was 50–60 metres and that it was completely depleted of nutrients.

The bulk of the standing crop of plankton was found above the discontinuity layer. The main phytoplankton organisms were: *Coscinodiscus*, *Trichodesmina* and *Ceratium* species. Of zooplanktonts the chief were copepods and sagittas. Scarcely any benthic animals were found in the depths where the oxygen content of the bottom water was less than 0·5 ml. per litre. In shallow water, benthos consisted mainly of hermit crabs, *Jibia curba* shells and a few nereid and polychaete worms.

The seasonal upwelling and the associated up-and-down movement of the layer of minimum oxygen caused by the changing monsoons have various important effects on the local fisheries. During the south-west monsoon the surface mixed layer will be rather thick and the layer of minimum oxygen correspondingly deep in the water off Bombay due to the piling up of surface waters. During the north-east monsoon the layer of minimum oxygen will gradually ascend into shallower depths because the surface waters will be blown seawards, so causing upwelling from below. The demersal fish which were distributed during the south-west monsoon over a large area on the relatively shallow continental shelf off Bombay will have to move into shallow water to escape lethal low-oxygen conditions. This chain of events will lead to the occurrence in shallow water during the north-east monsoon of fish concentrations

Station 1. I.N.S. *Ranjit*. October 24, 1958
Lat., 18° 51′ N.; long., 72° 29′ E.; depth, 42 m.

Depth of sample	Temperature (°C.)	Salinity (per mille)	Phosphate phosphorus (μgm. at./l.)	Dissolved oxygen (ml./l.)
Surface	28·5°	35·35	0·39	—
9 m.	28·1°	35·70	0·43	5·21
22 m.	24·0°	36·45	1·25	0·67

Station 2. I.N.S. *Madras*. November 4, 1958
Lat., 18° 51′ N.; long., 72° 27′ E.; depth, 43 m.

Surface	28·0°	35·66	0·45	2·90
5 m.	27·8°	35·86	0·40	5·11
15 m.	26·5°	35·95	0·53	3·06
25 m.	23·4°	35·99	1·20	0·87
32 m.	23·4°	36·13	1·25	0·68
39 m.	23·2°	36·04	1·35	0·45

Station 3. I.N.S. *Madras*. November 4, 1958
Lat., 18° 49′ N.; long., 72′ 34′ E.; depth, 26 m.

Surface	28·2°	35·37	0·42	5·12

Station 4*A*. Fishing vessel *Machwa*, KRJ 478. November 9–10, 1958
Lat., 18° 47′ N.; long., 72° 44′ E.; depth, about 14 m.
Start of rising tide

Surface	26·5°	35·88	0·93	2·6
5 m.	25·3°	35·91	1·09	1·75
10 m.	25·2°	(36·02)	1·06	1·25
12·5 m.	25·2°	35·91	1·09	1·2

Station 4*B* (same as Station 4*A*). End of rising tide

Surface	27·0°	36·22	0·56	1·25
5 m.	25·7°	36·17	1·09	1·20
10 m.	24·8°	36·04	1·13	1·4
12·5 m.	24·7°	35·82	1·16	0·5

Station 5. I.N.S. *Madras*. November 11, 1958
Lat., 18° 51′ N.; long., 72° 37′ E.; depth, 25 m.

Surface	27·0°	36·26	0·33	5·2
4 m.	26·9°	36·24	0·40	4·94
5 m.	26·55°	36·33	0·83	5·11
10 m.	26·25°	36·27	0·86	3·42
13 m.	24·85°	36·36	1·06	0·97
15 m.	24·4°	36·36	1·20	0·86
20 m.	24·4°	36·42	1·25	(1·00)

Station 6. I.N.S. *Madras*. November 11, 1958
Lat., 18° 49′ N.; long., 72° 44′ E.; depth, 12 m.

Surface	26·8°	36·26	0·71	3·30
5 m.	26·5°	36·24	0·86	3·14
8 m.	26·1°	36·11	1·31	4·29
10 m.	26·1°	36·09	0·71	3·03

easily available to the local fishermen and, in fact, there was a glut of landings soon after the start of the north-east monsoon in 1958.

The upwelling during the north-east monsoon causes also a high production of plankton off the Bombay coast, because nutrient-rich water is brought close to the surface, and it is naturally expected that pelagic fish would migrate into this area to feed on the rich standing crop of plankton then existing there. However, *Rastrelliger*, tunas, and Indian oil sardines do not come close to the coast in the Bombay area. It seems that these pelagic fish remain outside the 'upwelling and mixing zone' because of the low oxygen content of its water. Schools of pelagic fish were in fact sited at about 25 nautical miles off Bombay at the time to which this report relates.

The origin of the layer of minimum oxygen in the Arabian Sea is not yet fully understood, but it is associated with high salinities and relatively high temperatures, and several authors believe that it originates through the outflow of the Red Sea and Persian Gulf waters.

The seasonal behaviour of the surface layers of the Arabian Sea is not fully known. It would also be interesting to know the changes in intensity of the upwelling off Bombay during the north-east monsoon. From January onwards, the north-east monsoon

turns along the Indian Coast to north and north-west. This turning might cause considerable changes in the conditions to be found during October–November and described above for the period here concerned.

Currents

Very obviously it would help greatly in the understanding of the oceanographical situations discussed above if it were possible to make observations of the speed and direction of the bottom water movements at regular and frequent intervals around the clock—say, every half-hour for a lunar day on a number of separated occasions. We had certain suitable apparatus of great simplicity for making such current observations, but time did not serve. Only a few spot observations were possible using the very simple instruments developed by one of us (J. N. C.), but a notable current one-third knot in speed was measured running towards about 210° magnetic. This was at the position lat. 18° 51′ N., long. 72° 29′ E., and served to show at least that the bottom water was not setting constantly towards the coast at the time. Perhaps it might have been found to set dominantly shorewards later after the north-east monsoon had become more strongly established. If so (and the matter should certainly be investigated), a mechanism explaining the shorewards uptilt of the layer of minimum oxygen would be to hand.

We wish to thank the participants in the refresher course in marine biology who were engaged in the collection of the observations; the Indian Navy for the provision of shipboard facilities, and Mr. K. Koli, who kindly allowed us to use his boat.

[1] Schott, G., "Geographie des Indischen und Stillen Ozeans" (Boysen, Hamburg, 1935).
[2] Jayaraman, R., and Gogate, S. S., *Proc. Ind. Acad. Sci.*, **45**, 151 (1957).
[3] Gilson, H. C., "The Nitrogen Cycle", Rep. John Murray Exp., **2** (2), 21 (1937).

RUSSIAN CONTRIBUTIONS TO THE INTERNATIONAL GEOPHYSICAL YEAR

THERE are eighty-six scientific institutions in the Soviet Union taking part in the programme of the International Geophysical Year. They are organized by eighteen departments and ministries of which the most important are the Academy of Sciences, the Northern Sea Route Administration, the Hydrometeorological Service, and the Ministries of High Schools and Communication. The Soviet International Geophysical Year Committee publishes regularly an Information Bulletin giving details of the Russian investigations. It has also issued a bibliography of International Geophysical Year publications, arranged the issue of a series of commemorative postage stamps, and is preparing a full-length popular scientific film in colour dealing with its contributions to the International Geophysical Year.

Antarctica

Particular attention has been given to Antarctic research. The Academy of Sciences set up an Antarctic Expedition in 1955 and has established three main stations: Mirny (near Haswell Island), Vostock (near the south magnetic pole), and Sovietskaya (near the pole of relative inaccessibility). The two inland stations are more than 1,400 km. from the coast. There are also at present three further research bases. The Mirny Observatory carries out regular observations in nearly all the fields of the International Geophysical Year programme, such as meteorology, glaciology, oceanography, geomagnetism, ionospheric physics, seismology, and the study of cosmic rays and of Earth currents. The other stations are run on more modest lines.

A magnetic profile was made from Mirny to Pionerskaya, and from this the existence of a mountain ridge under the ice 250 km. from the coast was inferred. This was confirmed by seismic and gravimetric investigations, which showed that the ice is 2,500 m. thick in some places, and that substantial parts of the ground beneath the ice are below sea-level.

It was established that the Antarctic ice cap is shrinking, like that of the Arctic, but at a very much slower rate. The variation of temperature with depth in rocks was investigated, and in certain inland regions they were found to be frozen (that is, below 0° C.) to a depth of 200–300 m. Frozen rocks were found to thaw to depths of 0·1–2·0 m. in summer.

Geologists studied the coastal region between 80° and 110° E. Exposed rocks are scarce there, and mainly old pre-Cambrian crystalline schist and gneiss, intersected by vast granite intrusions, were found. This confirms the theory that this region is part of a shield. Metamorphosed sands and conglomerates were also found in this region.

An air survey was made of the coastline between 40° and 166° E., and maps have been published of this area. Three expeditions studied ocean currents, using the electromagnetic methods of measurement, and sedimentation and bottom structure, in a large part of the Antarctic Ocean.

The Arctic

In the Arctic, too, there has been a great deal of activity, particularly on the drifting ice stations. It was found that in summer, atmospheric pressure is abnormally low in the central Arctic and this disrupts the normal ice drift. It was also found that the ozone concentration is very great in March. A comparatively deep marine trench (up to 3,000 m.) was found between Greenland and Spitsbergen, which is of importance in the flow between the central polar basin and the North Atlantic.

Oceanography

The non-magnetic ship *Zarya* voyaged extensively (including a trip from Leningrad to Indonesia, crossing the Atlantic six times and visiting Australia via

Cape Town), and found anomalies even in the deep ocean, and determined the present position of the magnetic equator. The oceanographic ship *Vityaz* spent much time in the Pacific studying currents. It determined the boundary of the sub-arctic front between the Kuroshio and Oyashio currents, of the subtropical front between the Northern Trade drift and the North Pacific drift, and of the north (and south) tropical fronts between the Northern (and Southern) Trade drifts and the intertrade back drift. It found velocities of as much as 10–12 cm./sec. at 1,000 m. in certain places (instead of an anticipated maximum of about 3 cm./sec.). A new trench was found north of the Fiji Islands, and a part of the Marianas Trench was found to have the record depth of 10,990 m. Photographs of the ocean bottom were taken at depths of up to 9,800 m.

Rockets and Earth Satellites

By June 1, 1958, three satellites had been put into orbit and fifty-nine rockets fired, including one which reached a height of 473 km. From readings transmitted by the rockets the air pressure up to 260 km. was determined—at 260 km. it is of the order of 10^{-7} mm. mercury. A mass-spectrometer was taken up and it was found that, between 105 km. and 206 km., the main ions present have a mass number 30 (which is interpreted as NO ions). Dispersion interferometers were also taken up to measure the electron concentration in the ionosphere. It was confirmed that there is no clear layer at an altitude of about 110 km. but merely a region of maximum concentration of electrons. Beyond this the concentration of electrons falls slightly, and then increases to the *F*-layer, beyond which, contrary to the American observations, only a slow decrease was found. Animals were sent up in some of the rockets. They were recovered by parachute, and some of the animals made many trips. In the second satellite an animal was carried, and was found to behave normally in a state of free fall, and to manage well with other peculiarities of cosmic flight, during the week in which the air-regenerating apparatus was functioning. Ionospheric measurements made with the satellites confirm the results obtained with rockets. Observations of cosmic rays were obtained by means of the satellites; their intensities differed from the predictions of the present theories about the Earth's magnetic field. From the orbits of the satellites the density of the air layers through which they were passing was calculated, and found in some cases to be several times larger than the predicted values.

The third satellite was a veritable cosmic laboratory. It could measure the number and energy of micrometeorites hitting it, and carried a mass spectrometer. It measured its own electric charge, and the charges of the layers it passed through. It registered the atmospheric density and pressure, and carried a self-orientating magnetometer. It was also used for experiments on the control of orientation and internal temperature of the satellite vehicle.

Zodiacal Light, Meteorites and Earth Currents

An expedition to Egypt was organized to observe the zodiacal light and the polarization of the daytime sky, with specially developed instruments. These observations are being continued by the Helwan Observatory of the University of Cairo. The zodiacal light is also being studied at Aksenger, near Alma-Ata, in the U.S.S.R. (44° N., 76° E.), and by comparing these observations with those from Egypt it will be possible to find out how the properties of the zodiacal light depend on the ecliptical latitude.

In the U.S.S.R. eight stations have used radar to observe meteoric activity, and several formerly unrecorded streams of meteors were found, on January 15 and 16, 1958, for example, and on February 14 and March 9–15 of the same year. It was found that most sporadic meteors have elliptical orbits around the Sun, but some (less than 1 per cent of the whole) have been found which are definitely in hyperbolic orbits.

Earth-currents have been recorded continuously and pulsations of periods 1–4 sec. have been observed to occur simultaneously in the Arctic, Antarctic and middle latitudes. In the Antarctic large fluctuations occur in the amplitudes of the Earth potentials, up to about 1 volt/km.

Seismology

Seismic observatories were set up in the polar regions. There were six stations in the Arctic, and two in the Antarctic. These stations, in regions in which regular earthquake observations do not usually occur, give valuable information. The Antarctic stations observed about 600 earthquakes (in the two-year period beginning June 1, 1956), of which about 70 had epicentres south of 40° S.—however, no earthquakes have been detected which originated within the Antarctic mainland.

Microseisms were studied by many stations in the U.S.S.R. It was found that the microseisms observed in the European part of Russia originate mainly on the shores of Norway—no microseisms are observed when the storms are in the North Atlantic or on the shores of Greenland.

Okhotsk Sea—Pacific Ocean Structure

The crustal structure near the eastern coast of the U.S.S.R. was intensively studied. This region, extending to Kamchatka and the Kuril Islands, is of great interest. It has a high seismicity, with many shocks at all depths—this means that there is probably a deep major fault under the region. The deep seismic sounding method was used extensively; 3,300 km. of seismic profiles were taken at sea. The preliminary results show that the crust has different structures under the Okhotsk Sea, the Kuril Islands, and the oceanic plateau, with a thickening of the crust under the islands, and a substantial decrease of thickness under the oceanic plateau, where the crust is 12–18 km. thick (including the depth of the water). This region was covered also by aeromagnetic and sea gravitational surveys, and large anomalies were found (about 4,500 km. of sea gravitational surveys were taken).

The U.S.S.R. organizes the World Data Centre *B* for the International Geophysical Year: this has the task of collecting, keeping, and circulating data and results of all aspects of the work. Anyone wanting copies of such information should write either to Centre *B*1, Institute of Aeroclimatology, 33/35 Ulitsa Vorovskogo, Moscow; or Centre *B*2, Institute of Terrestrial Magnetism, 64 Chkalov Street, Moscow.

This article has been based on material supplied by Prof. V. V. Beloussov and V. A. Troitzkaya.

N. A. Routledge

OBITUARIES

Prof. Wolfgang E. Pauli, For.Mem.R.S.

UNEXPECTEDLY to all but those near him at the time, Wolfgang Pauli died on December 15, 1958, at the early age of fifty-eight.

Born in Vienna, Pauli graduated in Munich, and worked successively at Göttingen, Copenhagen and Hamburg. Nowadays, however, his name is mainly associated with Zurich, where he was professor of theoretical physics at the Federal School of Technology for the past thirty years, broken only by five years in Princeton during the Second World War.

Though Pauli died so young, it is no exaggeration to say that he was one of the leaders of theoretical physics throughout the past forty years. At the age of nineteen he was commissioned by his teacher, Arnold Sommerfeld, to write the article on relativity for the "Enzyklopædie der Mathematischen Wissenschaften". At that time, general relativity was novel and its literature scattered and understood by few. The young Pauli succeeded in presenting the entire subject in a work which was immediately recognized as masterly and which, in its scholarly precision, remains unsurpassed to this day.

Having demonstrated so early the depth and clarity of his insight into physical theory, Pauli did not take long to prove that as an originator of new ideas he was equal to the greatest. In 1924 he enunciated his 'exclusion principle' in terms of which so much of the then existing knowledge of atomic structure fell into order: we owe to Pauli the introduction of the two-valued variable required to characterize completely the state of an electron, and when, in 1925, Goudsmit and Uhlenbeck took the important step of interpreting their variable as an intrinsic angular momentum, it was Pauli again who showed how this concept could be consistently incorporated into the scheme of quantum mechanics and how the exclusion principle could then be formulated definitively as a symmetry requirement satisfied by the wave function of an atomic system. This also became the basis of the powerful concept of the Fermi statistics governing the behaviour of electrons. In 1945 Pauli was awarded the Nobel Prize for Physics, primarily for these achievements.

Though the nineteen-twenties undoubtedly represented a peak in Pauli's creative work, he in fact never ceased to produce work of comparable depth and to exert a profound influence on the development of physics. He continued both to bring forth new ideas and to clarify and consolidate the ideas of others. It was Pauli who, in an informal letter, first threw out the suggestion that an unknown, uncharged and massless particle was emitted in every radioactive β-disintegration. This entity, to which Fermi gave the name 'neutrino', to-day has an assured and important place in our picture of Nature.

We can only name a few of Pauli's great contributions to theoretical physics. With Jordan and with Heisenberg he laid the foundations of the quantum theory of fields, a subject still very much the concern of pioneering theorists, and when after 1945 great advances were made in this domain, mostly by physicists of the younger generation, Pauli, almost alone among the founders of quantum theory, participated directly in these developments. Previously, in 1940, he had firmly laid one cornerstone of field theory, by giving a proof of the long-conjectured relation between the spin and the 'statistics' of any elementary particle. This result, so closely related to his great work of the 'twenties, gave Pauli himself particularly great satisfaction.

Pauli's writings are in daily use among research workers everywhere. Perhaps the work most greatly admired is his article on the principles of wave mechanics in the "Handbuch der Physik", Vol. 24, 1933. Younger theorists may perhaps not realize how much the orientation and emphasis of research to-day owe to the guidance given by Pauli in this and his many other writings.

Those whose good fortune it was to be close to Pauli at one period or another know how much more has been lost by Pauli's death than can be put into words. As a personality, no one more deserves to be described as unique. His rotund build and characteristic gait, his gestures and mannerisms, his sharp tongue and gleeful laugh will all be remembered vividly by his friends. Anecdotes around him abound, and the legend of the 'Pauli effect', spelling disaster to any apparatus he approached, is all but believed throughout the world.

When in personal contact with Pauli it was impossible to lose awareness of all his characteristics and of the sense of the extraordinary in his nature. As many of his students discovered, communication with him did not always come easily, least of all through formal lectures. But once one was drawn into discussion, the barrier was surmounted and the experience of sharing his thoughts became infinitely rewarding. Through his large correspondence he extended his influence far beyond his own Institute. With Pauli's death many a physicist has lost a guide and critic without equal.

Not all of us had the privilege of sharing his deeper thoughts on questions transcending his own science. In his later years particularly, his studies extended into the philosophical domain and a number of writings scattered at present but shortly to be published in a collected English edition testify to this.

All those who can look back to personal contact with Wolfgang Pauli feel a deep sense of loss. He will be remembered by all as a great scientist, an unforgettable personality and a sincere friend.

N. KEMMER

Prof. A. C. Pigou

DURING the first half of the twentieth century, the University of Cambridge had a galaxy of brilliant scholars, scientists and thinkers. Prof. Arthur Cecil Pigou was among the greatest of them, and by his death on March 7 the University, and in particular his College, King's, have suffered an irreparable loss.

Prof. Pigou will be remembered by economists so long as the development of their science is studied. The favourite pupil of the great Marshall, and chosen by Marshall to be his successor in the chair of political economy, Prof. Pigou built on the foundations which Marshall had laid. By his teaching, his books, his articles in economic and other journals, his membership of Royal Commissions, and his letters in *The Times*, he played a major part in winning for economists the wide authority which they have to-day.

His most important work, "The Economics of Welfare", went through many editions, and was translated into many languages; it became, indeed, like his "Study in Public Finance" and his "Theory of Unemployment", a standard text-book in most schools of political economy throughout the world.

His title, "The Economics of Welfare", illustrates admirably his basic approach to his subject. In his introduction to the first version of his short book on "The Political Economy of War", he described it further; speaking of the "extraordinarily complex system of exchange built round the motive of private money profit", which it was his life's task to analyse, he described the "grave flaws of this system; it involves great waste; it has meant for very many human beings weariness, discontent, hunger and pain". The economists' hope, he said, was "that by carrying out well and truly this task of positive analysis, this economic anatomy and physiology, they might help other men, better trained than themselves for the practical work of government and administration, to fashion remedies or palliatives for the many evils they descry". He would never 'talk shop', if he could possibly avoid it; but those who were fortunate enough to have him as their teacher soon learnt the warm but practical idealism by which he was inspired.

They learnt, too, the splendid simplicity of his character, and the complete, uncompromising integrity of his heart and mind. Some of them, especially those with whom he climbed the rocks of Cumberland, and the mountains of Switzerland, Austria and Norway, came to know his unique gift for friendship, and his courageous determination as a leader, whatever the difficulties with which he met. In 1925, when he was only forty-seven, he strained his heart by climbing two peaks in the Alps in one morning, before he was fully trained; in spite of this 'fibulation', a week later he completed a long, unknown and difficult climb, only to collapse when he had brought his party safely off the rocks; from that point he was transported to his hotel on mule-back; yet only a week after that he accomplished what was, perhaps, his most difficult lead up the face of the Aiguille de la Za, circumventing an iced-up chimney by a route that could only be classed as exceptionally severe. It was a great climb; but the 'fibulation' which he then defied ultimately undermined his health, and brought his mountaineering to an untimely end.

Pigou was extremely shy with strangers—unless they were under ten years old. But when a little boy of five accomplished a walk at Buttermere over Scarth Gap and the Haystacks, and back by the Miners' path, Pigou was so moved by admiration that he invited the five-year-old hero, *and* his parents, to tea in his lovely house, Lower Gatesgarth.

There are many of his Cambridge friends to whom King's, without him, will never seem the same. King's was, indeed, a perfect setting for a life of such blameless goodness, and of such eminent academic and practical achievement. Those who were at Cambridge before the First World War will remember the warmth and power of his eloquence in Union debates, and his vivid interest in philosophy and poetry. Everyone who knew him will remember how he despised and hated the senseless folly of war. The epilogue to the second version of his "Political Economy of War", written in 1939, has the passion and the moving eloquence of the Gettysburg oration: "We are at a start of a journey whose end we cannot foresee. Yet once again the young and gallant, our children and our friends, go down into the pit that others have digged for them. Yet once again men of greater age, we that, if it might be, would so gladly give for theirs our withered lives, we cumber the earth in vain. We wait and watch and—those who can—we pray. As an economist I have not the power, nor, as a man, the heart, to strain through a night so black to a dawn I shall not see".

Cambridge will see no more his erect and striking figure walking along the Backs; but it will be long before the memory of his noble spirit has passed away.

Philip Noel-Baker

NEWS and VIEWS

Imperial Chemical Industries, Ltd.: Sir Ewart Smith, F.R.S.

Sir Ewart Smith, who is retiring from the board of Imperial Chemical Industries, Ltd., obtained first-class honours in the Mechanical Science Tripos at Cambridge. He joined Synthetic Ammonia and Nitrates, Ltd. (later the Billingham Division of Imperial Chemical Industries, Ltd.), in 1923, and later played a part in the major development of the huge Billingham complex, becoming its chief engineer in 1932. He was seconded to the Ministry of Supply in 1942 to be chief engineer and superintendent of armament design. He returned to Imperial Chemical Industries, Ltd., in 1945, when he was appointed technical director, and was knighted for his war-time services in 1946.

Sir Ewart's responsibilities as technical director, and since 1955 as a deputy chairman of the Company, have not precluded his devoting a great deal of time and energy to other organizations. As a member of the British Productivity Council—he was its chairman in the early and difficult days following its formation—he has been nationally respected and admired by management and trade union leaders alike for his progressiveness, forthright honesty and vigorous leadership

Sir Ewart has also served on numerous other bodies, governmental and scientific, including the Advisory Council on Scientific Policy, the Committee on Scientific Manpower, the Northern Ireland Development Council, and as a vice-president of the Institution of Mechanical Engineers. He was elected a Fellow of the Royal Society in 1957 in recognition of his contribution to technology, and this year is president of Section G (Engineering) of the British Association. He is keenly interested in education, and is a governor of Christ's Hospital, his old school. Sir Ewart is to serve as chairman of the new council set up to assist the application of modern industrial techniques in the National Health Service.

National Science Foundation Antarctic Research Programme: A. P. Crary

Albert P. Crary has been appointed chief scientist of the newly established United States Antarctic research programme within the National Science

Foundation. Mr. Crary, a noted polar geophysicist, recently returned from two and a half years in Antarctica, where he was station scientific leader of the Little America Station and deputy chief scientist of the Antarctic programme of the U.S. National Committee for the International Geophysical Year. The United States Antarctic research programme has been established to co-ordinate the scientific efforts of Federal agencies with an interest in Antarctic research and to receive proposals by university scientists and independent investigators for polar research. The Foundation looks to the Committee on Polar Research of the National Academy of Sciences—National Research Council for recommendations regarding the desirability of proposed programmes. Mr. Crary will advise the Foundation in the planning of the scientific projects, selecting personnel and equipment, and will supervise the conduct of field investigations, data analysis, and publication. Mr. Thomas O. Jones is director of the Antarctic research programme of the National Science Foundation. Mr. Crary will maintain offices at the Foundation and at Cambridge, Mass., where he will continue his affiliation with the Geophysics Research Directorate, Air Force Cambridge Research Center.

Geography at Sheffield : Prof. C. A. Fisher

Mr. Charles Alfred Fisher, at present reader in geography in the University of Leicester, has been appointed to the chair of geography in the University of Sheffield in succession to Prof. D. L. Linton (see *Nature*, 182, 497 ; 1958). Mr. Fisher, who will take up his appointment in October, graduated at Cambridge with first-class honours in both parts of the Geographical Tripos. He was awarded a University Bartle Frere Research Exhibition in 1938 and for the next two years he undertook research at Cambridge. After nearly six years in the Army, Mr. Fisher took up an appointment in January 1946 as an assistant lecturer in geography at University College, Leicester, and later that year was appointed to a lectureship in geography at the University College of Wales, Aberystwyth, which he held until December 1949. Before returning to Leicester as a lecturer in 1951, Mr. Fisher held an appointment as senior research officer at the Institute of Colonial Studies, Oxford. In October 1958 the title of reader in geography in the University of Leicester was conferred on him.

In 1947 Mr. Fisher was awarded a Travelling Fellowship of the Royal Geographical Society which enabled him to make a series of study visits to Dutch universities and the Tropical Institute of Amsterdam in connexion with his researches on South-east Asia, and during the session 1953–54 he was a visiting lecturer in geography at Yale University, and was appointed Visiting Fellow of Trumbull College, Yale. Mr. Fisher has contributed chapters to several books and has published many articles on a wide range of geographical subjects, particularly on South-east Asia and the Far East.

Nuclear Technology at the Imperial College of Science and Technology, London

Courses of instruction and postgraduate research in the various branches of nuclear science and engineering given at the Imperial College of Science and Technology, London, include those on the theoretical and practical aspects of nuclear and high-energy physics (Physics and Mathematics Departments) ; a postgraduate course in nuclear power (Department of Mechanical Engineering) ; and a new course in nuclear technology (chemical) (Chemical Engineering Department). This one-year course, which commences in the session 1959–60, is under the supervision of Mr. G. R. Hall, reader in nuclear technology, assisted by Dr. H. D. Evans, Mr. S. Hartland and Dr. A. J. Swallow. In addition to topics relating to nuclear power production, such as fuel-element technology and the processing of irradiated fuels, a substantial part of the course will be devoted to the applications of radioisotopes as tracers and for non-destructive testing, and the possible uses of sources of radiation for inducing industrial-scale chemical reactions. Applications for admission should be made before June 1, on a form obtainable from the Registrar, Imperial College of Science and Technology, London, S.W.7.

Nuclear Training in the Biological Sciences in the United States

The United States Atomic Energy Commission has approved thirty-two new grants totalling 316,717 dollars to thirty-one American colleges and universities. These grants are part of a programme to assist colleges and universities to expand their facilities for training in radiation biology and in the use of radioisotopes in the fields of agriculture, veterinary medicine, medicine and pharmacy, public health and biology. The new grants bring to 1,810,707 dollars the total amount awarded in making 152 grants to 110 institutions since the Commission's programme was initiated in October 1957.

The Australian National University : Field Station for Astronomy

About a year ago the Department of Astronomy (Mount Stromlo Observatory of the Australian National University) initiated a survey to locate a suitable site for a field station. Excessive night cloudiness in Canberra and vicinity renders it impracticable to carry out at Mount Stromlo sustained long-range observational programmes. The intention is not to transfer major equipment from Mount Stromlo to the field station, but the University may want to place some future new equipment there rather than at Mount Stromlo. There is no question of transferring any of the research, teaching or administrative activities to the site of the field station. During the past year, tests for night cloudiness have been carried out at four localities, all of which are hill tops rising 700–1,000 ft. above the level of the surrounding plain, three in New South Wales and one in Victoria. According to the records gathered to date, Natimuk (Victoria) has the largest percentage of clear nights (65 per cent over 122 nights), Griffith has 54 per cent over 266 nights, Condobolin 47 per cent over 263 nights. Mount Stromlo had only 28 per cent clear over the same interval. Alectown and Lake Cargellico both show 40 per cent clear. All observations refer to the first half of the night.

Astronomical tests are to be initiated at various sites, notably near Natimuk, Griffith and Condobolin. Provided arrangements can be made for temporary occupation of the site, access roads, electricity supply and telephone service, a control station will be set up near Griffith and one of the smaller telescopes from Mount Stromlo Observatory will be moved there, with the intention of operating it for a period of eighteen months. Mobile telescopic equipment

will be set up at the other sites under consideration, and each site will probably be occupied several times for periods of about two weeks at any one time.

Russian *Journal of Inorganic Chemistry*

Starting with the January 1959 issue, the Chemical Society is to publish, with the support of the Department of Scientific and Industrial Research, a cover-to-cover translation of the monthly journal, *Zhurnal neorganicheskoi Khimii*, a publication of the Academy of Sciences of the U.S.S.R. The translation will be undertaken for the Society by Infosearch, Ltd., and the Society has appointed Prof. P. L. Robinson as executive editor. He will be assisted by an advisory panel of distinguished inorganic chemists. The sale and distribution of the journal will be undertaken by Cleaver-Hume Press, Ltd., 31 Wright's Lane, London, W.8, from whom a detailed prospectus giving the scope of this journal may be obtained. Translations will be issued in monthly parts as soon as possible after the Russian original is available. The subscription rate will be £30 (United States, 90 dollars) per annum, but universities and technical colleges may subscribe at a discount of 25 per cent. Single issues can be purchased at £4 (12 dollars) per copy. The Society also hopes to start the publication within the next year of translations of the Russian *Journal of Physical Chemistry* (*Zhurnal fizicheskoi Khimii*) and *Progress in Chemistry* (*Uspekhi Khimii*).

School Mathematics

Useful comments on the teaching of mathematics in schools are to be found in the Spring 1959 issue of *Forum* (1, No. 2). The headmaster of a junior school, the head of the mathematics department at a comprehensive school and a university professor of mathematics all agree that the aversion to mathematics which is found in so many intelligent adults was implanted in the primary school. According to one observer, mathematics in the primary school consists entirely of computation. "Available text-books present dreary, intelligible masses of sums instead of challenging children to think, to reflect on how, when and where, with numbers and space relationships." Instead of imparting an appreciation of number relationships in the way advocated by Piaget, most mathematics teaching in primary schools consists of a series of tricks which have little connexion with the life of the child. Suggestions for making the teaching more related to the child's experience are described in two of the articles, while Prof. R. L. Goodstein, of the University of Leicester, also advocates research to find a more enlivening syllabus and more successful methods of presentation.

Control of Exhaust Fumes

In reply to a question in the House of Commons on March 24 regarding research into the control of the emission of diesel oil and petrol exhaust fumes from vehicles, Mr. H. Nicholls said that the results of work on combustion in diesel and petrol engines, carried out by the Motor Industry Research Association and the British Internal Combustion Engine Research Association and elsewhere, showed that the greater part of the smoke from such engines could be prevented by proper adjustment, running and maintenance. The Warren Spring Laboratory of the Department of Scientific and Industrial Research had tested a catalytic device which effectively reduced the pollution from petrol engine fumes. Mr. Nicholls agreed that unpleasant fumes were often due to absence of proper maintenance.

National Research Development Corporation of India

The fourth annual report of the National Research Development Corporation of India, which includes the statement of accounts for the period ending March 31, 1958 (pp. 20. New Delhi: National Research Development Corporation of India, 1958), records 59 inventions reported for development by eighteen research institutions and individuals, making a total of 447. Five new patent applications were filed and seventeen new licence agreements were negotiated. New projects for refining cotton seed oil, for white cement from feldspar, and for a fluidized-bed technique for textile processing were instituted, and a project for pine oil from Indian turpentine was completed. Progress is reported in those for production of phthalic anhydride by fluidized-bed oxidation of coal tar oils, for copper chlorophyll, for bamboo mechanical pulp, the de-ionization of sugar cane juice and for a thermoelectric generator.

The Civic Trust

Founded just over a year ago to ensure that community developments are made with good taste and dignity and to give delight to all inhabitants, the Civic Trust has already acquired a momentum which should lead to a future of promise and fulfilment. In collaboration with the B.B.C. Television Service, four useful films have been produced showing how the Trust is waging war on ugliness. The threatened demolition of part of the Close of Dunblane Cathedral has been averted by prompt intervention by the Trust. As the first of a series of 'live' experiments, Magdalen Street, Norwich, is being redecorated in accordance with an over-all scheme prepared by the Trust. The Trust is also to develop a system of amenity awards, the objects of which are to encourage good local architecture and building of all kinds which can be said to make a desirable contribution to the civic and rural scene as a whole, and to stimulate interest in all other types of physical development. Details of the awards can be obtained from the Civic Trust, 79 Buckingham Palace Road, London, S.W.1.

South Australian Museum

The most recent issue of the *Records of the South Australian Museum* (13, No. 2; 1958) forms another sumptuous part of the current volume, with 156 pages of text and twenty-four excellent plates. Most of the papers are by members of the staff of the South Australian Museum and include contributions on the aboriginal cave paintings at Sleisbeck, a revision of the ghost moths, new cretaceous fossils from New Guinea, Australian beetle-mimicking bugs of the family Lygaeidae, and on the Potoroinea (a group of central Australian mammals). Such a publication gives evidence of a progressive museum with a staff undertaking research of a high order.

Aviation Psychology

The military Air Forces and civilian air lines of every country are aware of the many psychological factors involved in safe flying, and of the difficulties in selecting and training suitable air-crew. But only in the United States and, to a lesser extent, in Britain are there sufficient psychologists employed in the field of aviation to develop a systematic attack on these problems. Thus in an attempt to co-ordinate and further their activities, the aviation psychologists of Western European countries have formed an association; and a recent monograph (Aviation

Psychology in Western-Europe and a Report on Studies of Pilot Proficiency Measurement. Publication No. 1 of the Western-European Association for Aviation Psychology. Pp. 64. Amsterdam: Swets and Zeutlinger, 1958. 15s.) contains a series of reports on the present position of their work from representatives of most of the countries concerned; the absence of British civilian air-line representatives is conspicuous. It is interesting to learn that most Air Forces or companies are achieving better selection of pilots by scientific testing (despite considerable variations in the relative emphasis placed on paper-and-pencil tests, apparatus tests and clinical assessments). But it is disappointing to find so little attention, outside the British Institute of Aviation Medicine, to 'human engineering' and training problems such as the effects of stress and fatigue on air-crew, and the design of aircraft equipment and simulators (synthetic training devices). Much the most stimulating paper is one contributed by the American psychologist, Dr. C. W. Bray, on the detailed recording of pilot performance.

Statistical Review of England and Wales for 1956

THE Registrar General has recently issued the Commentary Volume on the Statistical Review of England and Wales for 1956 (pp. xvi+294. London: H.M. Stationery Office, 1958. 16s. 6d. net). As has become established practice, this volume includes some special analyses, as well as commentary on the vital events of the year to which it relates. There is included a nuptiality table for 1951–55, which has been computed in connexion with the fertility analysis of the 1951 census. Such a table is similar to a life-table, but shows the survivors at various ages up to fifty by marital status. The very high rates of marriage prevailing in 1951–55 are indicated by the fact that of 100,000 females, 90,656 survive to age fifty, of whom only 4,837 have never been married. Of the group of males surviving at age fifteen, only half are still single at twenty-five; in the case of females the corresponding age is twenty-two. Another special feature included is a comparison of causes of death as ascertained after autopsy with those given on death certificates. The comparison applies to deaths occurring in a number of selected hospitals, and deaths certified by general practitioners are not included. It is shown that in 19 per cent of all cases, new facts were ascertained by the pathologist which had not been reported by the clinician. It was also apparent that deaths from cancer of the lung were under-recorded, in spite of the greater diagnostic facilities that were available.

Insect Toxicologists' Information Service

AT a meeting held during the tenth International Congress of Entomology at Montreal, insect toxicologists agreed to co-operate with Dr. D. Dresden of the University of Utrecht in establishing an Insect Toxicologists' Information Service. The first Bulletin of the information service was issued recently (Insect Toxicologists' Information Service, Bulletin No. 1. Pp. 106. Vondellaan 6, Utrecht, 1958) by Dr. Dresden. The object of the Service is to enable insect toxicologists all over the world to keep in touch with one another and to be kept up to date with each other's research activities. The Bulletin, which is to be issued annually, is designed for this purpose. The names of the workers on insect toxicology are given, with the laboratory in which they work and some indication of their interests. Some account is also given of the biological material that they work with, since interchange of material may facilitate research. The main body of the Bulletin consists of short notes from the workers themselves on the work they are doing, and it is necessary to submit these notes in order to receive a copy of the Bulletin. Providing the insect toxicologists fulfil their promise to co-operate with Dr. Dresden by submitting their notes regularly, this service should greatly benefit research in this field.

The Nessim Habif Prize

THE University of Geneva will award in 1959 the Nessim Habif Prize of 10,000 Swiss francs to an author of a work or to an inventor who has made an important contribution to the knowledge or uses of plant cellulose or its synthetic derivatives. Manuscripts must be submitted by May 1 to the Doyen de la Faculté des Sciences de l'Université de Genève, Université, rue de Candolle, Genève, from whom further information can be obtained.

Harkness Fellowships of the Commonwealth Fund

THE British Committee of Award of the Commonwealth Fund has announced the following elections, among others, to Harkness Fellowships for 1959, tenable for one or two years in the United States: R. H. Cassen (London School of Economics), economics; C. B. Cox (King's College, London), palæontology; R. N. Curnow (Aberdeen), biostatistics; V. J. Emery (Clare College, Cambridge), nuclear physics; C. W. J. Granger (Nottingham), economics; J. F. Hodgess Roper (Magdalen College, Oxford), international economics; S. C. Hunter (Armament Research and Development Establishment), theoretical mechanics; J. L. Jinks (Birmingham), genetics; A. D. McLachlan (Trinity College, Cambridge), theoretical chemistry; G. P. McNicol (Glasgow), medicine; W. T. Norris (Pembroke College, Cambridge), engineering; M. L. V. Pitteway (Queens' College, Cambridge), radio physics; D. C. Smith (Queen's College, Oxford), botany; J. B. Taylor (Atomic Weapons Research Establishment), theoretical physics.

International Oceanographic Congress

THE American Association for the Advancement of Science is to hold an International Oceanographic Congress at the United Nations Building in New York, during August 31–September 12. The Congress is being planned in co-operation with the International Advisory Committee on Marine Sciences of Unesco and the Special Committee on Oceanic Research of the International Council of Scientific Unions. The Congress has the endorsement of the International Association of Physical Oceanography of the International Union of Geodesy and Geophysics. The programme has been designed to afford discussion among scientists interested in diverse fields of specialization within oceanography. Governments as well as universities and scientific organizations abroad are sending delegates to the Congress. It is also suggested that research vessels be sent to New York for the duration of the Congress, to make it possible to exhibit instruments used at sea and to display the most recent data and collections of biological and geological samples and chemical techniques. Further information can be obtained from the American Association for the Advancement of Science, 1515 Massachusetts Avenue, N.W., Washington 5, D.C.

Announcements

Prof. A. R. J. P. Ubbelohde, professor of thermodynamics at the Imperial College of Science and Technology, London, has been appointed director of the Salters' Institute of Industrial Chemistry on the retirement of Sir Alfred Egerton on June 30.

Allan Ray Putnam has been appointed managing director of the American Society for Metals, a new position established by the Board of Trustees following the death last May of William H. Eisenman, who was national secretary and executive head of the Society for forty years.

Mrs. Elwyn Davies, of Llandaff, Cardiff, who is a member of the Archæology and Art Committees of the National Museum of Wales and of the Board of Celtic Studies of the University of Wales, and Mr. John C. P. de Winton, of Brecon, have been appointed members of the National Parks Commission. Mrs. Davies will fill the vacancy left by the late Lady Hopkin Morris, and Mr. de Winton, who is a member of the Breconshire Education Authority, has been appointed as another representative of Welsh interests.

The following were recently elected as officers and members of Committee of the Society for the Bibliography of Natural History: *President*, Dr. J. Ramsbottom; *Hon. Secretary and Treasurer*, A. C. Townsend; *Committee*, G. F. Elliott, Dr. F. C. Fraser, F. J. Griffin, W. T. Stearn, C. K. Swann, Dr. D. W. Tucker.

The annual general meeting of the Antiquarian Horological Society will be held at the Science Museum, South Kensington, on May 1. The new honorary secretary of the Society is Mr. J. C. Stevens, 53 Woodfield Crescent, Ealing, W.5, from whom further information can be obtained.

A meeting will be held to consider a proposal that an International Congress on Corrosion be held in London in 1961 under the sponsorship of the Society of Chemical Industry. The meeting will be held at 14 Belgrave Square, London, S.W.1, at 3 p.m. on April 20, and all persons interested in the proposal are invited to attend.

The fifteenth Annual National Electronics Conference will be held at the Hotel Sherman, Chicago, during October 12–14. Abstracts, no longer than two hundred words, must be received by Mr. E. Van Valkenburg, Electrical Engineering Department, University of Illinois, Urbana, by May 1.

The second international conference on Medical Electronics will be held in the Unesco Building, Paris, during June 24–27. Further information can be obtained from Dr. C. N. Smyth, University College Hospital, Gower Street, London, W.C.1.

The twelfth Brookhaven Symposium in Biology, on Structure and Function of Genetic Elements, will be held during June 1–3. Sessions will be held on: structural aspects of nucleic acids; biochemical activities of nucleic acids; the gene; structure and duplication of chromosomes; nuclear–cytoplasmic relationships. Further information can be obtained from Dr. M. Levine, Brookhaven National Laboratory, Upton, New York.

The second symposium on X-ray Microscopy and X-ray Microanalysis will be held in Stockholm during June 15–17. The symposium will deal with new developments in X-ray microscopy and X-ray microanalysis as well as applications of these techniques. Further information can be obtained from Dr. G. Höglund, Institutionen för Medicinsk Fysik, Karolinska Institutet, Stockholm 60, Sweden.

The Italian National Committee for Nuclear Research is organizing a Congress on Nuclear Energy to be held in Rome during June 16–20, during the Sixth International Exhibition on Electronics and Atomic Energy. Further information can be obtained from the secretary of the Congress, Mr. Roberto Levi, Comitato Nazionale per le Ricerche Nucleari, Via Belisario 15, Rome.

The Advisory Group for Aeronautical Research and Development of Nato is holding a meeting on "Chemistry of Propellants" in the Nato Headquarters Building, Palais de Chaillot, Paris, during June 8–12. During the first four days the following themes will be developed: (1) properties and preparation of propellants; (2) theoretical and experimental performance evaluation; (3) fundamental studies; (4) sources, availability, and estimated costs of propellants. The fifth day will be devoted to a round-table discussion on "Basic Problems in Propulsion".

The European Conference for Industrial Management on "Industrial Prospects in Nuclear Energy", organized by the European Nuclear Energy Agency, will be held at the Palais des Congrès, Stresa, during May 11–14. There will be eight sessions, devoted respectively to a survey of European nuclear energy programmes; the economics of nuclear power; financing such programmes; legal problems involved; management problems; the market for materials; the market for equipment; and the market for instruments. Further information can be obtained from the Information Officer, European Nuclear Energy Agency, Organization for European Economic Co-operation, 38 Boulevard Suchet, Paris 16e.

The Development Commissioners, in association with the Ministry of Agriculture, Fisheries and Food and the Scottish Home Department, are prepared to award postgraduate training grants in fishery research tenable from October 1, 1959. These grants are intended to enable selected candidates to undergo a specified course of training to fit them for the investigation of problems in marine or freshwater science. Candidates must be nominated by a senior member of a university department. Provisional applications will be accepted from candidates who have not yet sat their final examination or who have not yet been informed of the result. Further details and forms of application, returnable by May 20, can be obtained from the Secretary, Development Commission, 3 Dean's Yard, Westminster, London, S.W.1.

Cornell University annual summer Laboratory Course in Techniques and Applications of the Electron Microscope is to be held during June 15–July 3. The course is planned to meet the needs of senior research workers in the field of electron microscopy. Registrations will be limited in number, to provide ample facilities for the members to pursue extensive laboratory work in their special fields, at introductory or advanced levels depending on their previous experience. The course of lectures is designed to give members an intensive survey of basic theory, as well as interpretation of results and application to research problems. Further information and forms of application can be obtained from Prof. B. M. Siegel, Rockefeller Hall, Cornell University, Ithaca, New York.

HYPERSONIC FLOW

ON December 15, some two hundred representatives of the research establishments, the aircraft industry and the universities attended an all-day discussion on hypersonic flow sponsored by the Royal Aeronautical Society and held, under the chairmanship of Dr. G. W. H. Gardner (Royal Aircraft Establishment, Farnborough), in the rooms of the Institution of Mechanical Engineers.

An introductory paper surveying the problems of hypersonic aerodynamics was read by Mr. R. J. Monaghan (Royal Aircraft Establishment, Farnborough). The term 'hypersonic' can generally be applied to flight at Mach numbers greater than about 5, for it is at speeds of this order that the linearized equations of supersonic flow become inadequate, boundary layers of increased thicknesses begin to interact appreciably with flow fields around slender bodies and aerodynamic heating assumes major importance. A further boundary occurs at Mach numbers of the order of 8–9, when there is sufficient kinetic energy to provide some dissociation of the oxygen molecules in air, and the amount of dissociation increases with increasing Mach number above this value.

In designing for the alleviation of aerodynamic heating there are two distinct cases. The first relates to the uncontrolled re-entry of a freely falling body, for which a high-pressure drag shape is required; the second refers to sustained flight, for which a shape with low-pressure drag is probably better, radiation giving appreciable control of surface temperature. Low-pressure drag accords with design for aerodynamic efficiency and there is scope for research on three-dimensional lifting shapes.

The strong curved bow wave moving ahead of the body which is a characteristic of hypersonic speed implies that no real distinction can be drawn between blunt and sharp noses; moreover, the necessity for avoiding excessive rates of heat transfer means that the nose must be blunted. Some distinction can be made, however, between bodies in which the curvature varies slowly along the surface, and flat-faced bodies in which a distinct shoulder occurs.

In his paper on general characteristics of hypersonic flow fields, Dr. R. N. Cox (Armaments Research and Development Establishment, Fort Halstead) gave a historical survey of early work on hypersonic flow and discussed the problems of predicting pressure distributions over blunt-nosed slender bodies.

Expressions have been obtained by many authors for predicting these pressure distributions, but unfortunately the estimates do not agree with experimental measurements. It has now become generally accepted that the magnitude of viscous interaction is a function of Reynolds number based on the thickness of the leading edge; above a certain value of this Reynolds number (that is to say, if the leading edge is blunt) the pressures induced near the leading edge of a body are almost entirely due to inviscid flow effects. Afterwards, there had been much theoretical work on the details of inviscid flow fields, and some promising approximate methods have appeared—for example, the use of Newtonian flow followed by a Prandtl–Meyer expansion for flow over round noses, and the application of the intense blast-wave analogy for predicting induced pressures over the rear portion of the body.

Problems of truly blunt bodies were considered by Dr. K. W. Mangler (Royal Aircraft Establishment, Farnborough) in his paper on special aspects of hypersonic flow fields. Following the bow wave ahead of a blunt body is a region of subsonic flow, and very reasonable estimates of the flow variables in this region can be obtained from inviscid theory, provided that allowance is made for the variation of entropy across the shock, and that the equation of state is adjusted to make allowance for the different degrees of freedom excited in the molecules of the gas. Accordingly, consideration was given to a theoretical model of an inviscid flow at very large Mach number and with a ratio of enthalpy to internal energy approaching unity. Attempts to extend this work to cover the more general case of arbitrary large Mach numbers and more realistic values of the enthalpy – internal energy ratio have shown the necessity for adopting numerical techniques.

Many of these techniques deal with the inverse problem of finding the body to fit a given shock shape, which simplifies the procedure considerably, and on these lines a marching technique can be devised. The non-viscous concept gives satisfactory results for the forward-facing surface, but, behind the shoulder of the body, viscosity has to be taken into account, and it is necessary to match the values of the flow properties at the outer edge of the boundary layer with those of the flow entering from the inviscid region.

A paper on hypersonic boundary layers with special reference to aerodynamic heating by Dr. L. F. Crabtree (Royal Aircraft Establishment, Farnborough) emphasized the importance of the leading edge in problems of heat transfer. The rate of heat transfer to a bluff body, including dissociation effects, can be investigated analytically.

The dense layer of air near a highly cooled surface is relatively unaffected by pressure gradients along the surface, a concept which proved very useful in calculations of turbulent boundary layers for blunt bodies; if true local conditions are used, the intermediate enthalpy method is very useful, for undissociated flow, for both laminar and turbulent boundary layers at Mach numbers up to 10.

Dr. K. W. Mangler had mentioned the problems of lifting bodies with their associated problems of vortex and bubble type separations. From the point of view of low drag the former would appear preferable, but a planned use of the latter also has possibilities; for example, a spike protruding from the nose of a blunt body can reduce the drag. However, difficulties arise in this case, since experiments have shown high heating-rates when the flow becomes re-attached; indeed, the overall heat transfer might be higher than on the basic bluff body without a spike. Other methods have been suggested for the reduction of aerodynamic heating-rates, including ablating surfaces and transpiration cooling; for the latter method, experiment has shown that quite modest amounts of coolant blown through a wall can produce a considerable reduction in the heating-rates.

Methods of studying experimentally some of the problems of hypersonic flows were surveyed by Dr. D. W. Holder (National Physical Laboratory, Teddington). Some of the new problems can be studied with techniques which do not differ in principle from those used in research at supersonic speeds. However, to simulate fully the very high temperatures of hypersonic flight it is usually necessary to employ heaters or tunnels of unconventional design, frequently having a very short running time, or to make tests with a model launched or propelled at a very high velocity. In such tunnels the working gas is usually heated by compression, in a shock tube or by a system of shock waves, or by the discharge of electrical energy.

In addition to the usual wind-tunnel measurements of aerodynamic loading and heat transfer, the pressure, temperature and density of the working gas are required; the degrees of dissociation and ionization and their variation with temperature and time are other properties which have to be measured within the brief period of steady flow provided by the test facility.

Types of facility at present in use include helium tunnels, arc-heated and plasma jets, hypersonic gun-tunnels, shock tubes, shock tunnels, 'hot-shot' arc-driven tunnels, free-flight wind-tunnels and free-flight rocket-propelled models; none of these is able to simulate fully all the required conditions, but each is able to assist in investigation of the problems of some part of the hypersonic regime.

Prof. M. J. Lighthill (University of Manchester) began his paper by a detailed study of the dynamics of dissociating oxygen. Two mechanisms of dissociation exist, one by collision with another particle, the other by absorption of a photon of light. The wave-lengths of light required are in the ultra-violet range (especially 1300–1750 A.), and although at high altitudes the wave-lengths are present in sunlight, they are almost entirely absorbed by the dissociation mechanism. There is practically no light of this wave-length present at altitudes less than 60 km., and at lower altitudes all dissociation is due to collisions.

Conversely, recombination can be effected in two ways: three-body recombination and two-body combination with emission of light. The latter predominates at very low densities, say, less than 10^{-8} gm./cm.^{3}. Where aerodynamic forces are important, three-body recombination is more likely to occur.

The energy required to dissociate an oxygen molecule can be described as the kinetic energy that it would have if its speed were 5·5 km./sec. Thus, some dissociation will occur around any body travelling through oxygen at this speed. Not all molecules will be dissociated, for some of the energy will go to increase the translational, vibrational and rotational energy of the molecules.

On passing through the shock wave ahead of the body, the kinetic energy of the molecule is converted almost entirely to translational and rotational energy, and a transitional region exists before dissociational equilibrium is reached; however, equilibrium is reached so rapidly that no direct measurements of satisfactory accuracy have been made in this region.

During dissociation the pressure increases, and this has the effect of compressing the air cap between the shock wave and the body. At very low densities the thickness of the boundary layer is comparable with that of the compressed air cap, and it has been concluded that if the surface were cooled to a temperature not much greater than that of the free stream, then the cooled boundary layer would have an effective negative displacement thickness.

A paper by Dr. J. A. Shercliff (University of Cambridge) on possible aeronautical applications of magnetogasdynamics began by stating that, in the equilibrium state, the ionization process is amenable to the same thermodynamic and statistical-mechanical treatment as the dissociation process. However, it is possible in hypersonic flow that ionization, like dissociation, can fail to reach equilibrium, and the ionization relaxation process behind a bow shock wave can occupy a region comparable in extent with the dimensions of the vehicle.

Magnetogasdynamics is generally understood to exclude the type of electron behaviour which belongs to plasma physics, and the thermodynamics of the gas is considered to be unaffected by the magnetic field.

The interaction of velocity fields with magnetic fields produces the novel features of magnetogasdynamics, and many parallels with fluid dynamics exist—for example, the so-called magnetic Reynolds number measuring the relative power of the convective and diffusive processes. If this is large, a magnetic boundary layer occurs (the skin effect, well known to electrical engineers), but in aeronautics, magnetic disturbances diffuse much more rapidly than viscous disturbances, and the viscous boundary layer can be ignored when studying the field distortion.

In aeronautics the most obvious application of magnetogasdynamics lies in its use to modify forces on, or heat transfer to, a vehicle. Drag can be produced in midstream away from the surface of a body, heat transfer to stagnation points and skin friction can be reduced by suitably orientated magnetic fields, and transition or separation of the boundary layer can be controlled. An interesting application is that in which an electrical field supplies energy through electrodes to air, accelerating it for propulsive purposes, or the converse case in which air in motion is used to generate electrical energy, which is then supplied to the vehicle to drive auxiliary systems.

The weight penalty will probably confine the use of electromagnetic rockets to interplanetary space vehicles assembled in satellite orbits. Land-based experimental facilities are not affected by the weight penalty and the possibility of high-enthalpy test plant seems attractive. Another possible use lies in the reduction of heat transfer to hypersonic nozzles.

The final paper, on aerodynamic problems of manned space vehicles, was given by Mr. T. R. F. Nonweiler (The Queen's University of Belfast). Any analysis of a project designed to carry a man into orbit and return him safely to Earth must consider the need to limit the accelerations and retardations of his passage and the temperature of his environment. There is no need to fear excessive accelerations in a powered ascent; even with existing fuels a two-stage rocket would not necessarily involve accelerations of more than 10 g.

Descent from an orbit could be effected by the use of a glider vehicle employing aerodynamic lift; an alternative is the so-called 'parachute re-entry' using aerodynamic drag, although whether or not a 'parachute' is employed is immaterial, for if the shape and drag of the vehicle remain constant the deceleration always has the same characteristic

variation in time, reaching a maximum value of about 8*g*. Deceleration and aerodynamic heating, except in the region of the leading edge, are much reduced by employing lift in the descent, although the provision of lifting surfaces entails an increase in weight of the vehicle and the unusual stability and control characteristics pose interesting problems.

The most critical conditions will probably be encountered not in the return from a successfully accomplished orbit, but in emergency re-entry from an abortive ascent. In meeting this contingency there appears to be some advantage in the glider type of vehicle rather than the zero-lift type, but the evidence is by no means conclusive at present.

The question of a successful landing involves many possibilities. An airfield would be a remarkably elusive target in an unpowered glide which, as a result of emergency or mistake, might be initiated over the Pacific Ocean. Probably the glider would have to be regarded as expendable, the occupant being ejected by capsule at a low altitude.

B. E. Beadle

INTERFACIAL PHENOMENA

THE biennial conference of the Physical Society, on solid state physics, was held during December 18–20 at the Cavendish Laboratory, Cambridge, under the general title of "Interfacial Phenomena". The conference was attended by about two hundred delegates and twenty-eight papers were presented, which fell into three major groups describing, respectively, various effects associated with films deposited in vacuum, the nature of solid – liquid interfaces and the formation of electrodeposited films, and the structure and properties of internal surfaces. The conference brought together physicists, physical chemists and metallurgists, each with a different approach to the study of interfacial phenomena.

In introducing the papers on films deposited in vacuum, D. W. Pashley (Tube Investments Laboratory, Hinxton Hall) gave first a brief historical survey of the experimental work on the growth of oriented deposits on substrates. He defined the terms 'epitaxy' and 'misfit' and showed that under some conditions epitaxy only occurred with a misfit of less than 15 per cent, but that in many cases misfits of much larger than 15 per cent could be tolerated. The limitations of the various techniques used for the investigation of epitaxy were then outlined, the great power of the electron microscope being emphasized.

The potentialities of the electron microscope in this field of study were fully exploited by G. A. Bassett (Tube Investments, Hinxton Hall). His experiments on nucleation, orientation and growth of vacuum-deposited metal films on ionic and metallic substrates showed that an oriented layer of gold of about 10 A. mean thickness, deposited on a single-crystal silver substrate, formed nuclei of 20–200 A. diameter which grew in size rather than number until a continuous film was formed at a mean deposit thickness of about 50 A. When gold was deposited on rock salt a similar effect was observed, but there the gold nuclei formed preferentially at slip and cleavage steps on the rock salt surface.

Reflexion electron diffraction techniques were used by R. C. Newman (Associated Electrical Industries, Aldermaston), A. Glossop and D. W. Pashley (Tube Investments, Hinxton Hall), to study the deposition of copper on silver maintained at different temperatures. They found diffraction patterns characteristic of copper with its normal lattice constant when the mean film thickness was 0·8 A. and the substrate temperature 20° C., but by increasing this temperature to 300° C. copper patterns were obtained at a mean film thickness of 0·2 A. These results showed that at above a critical mean thickness of much less than one atomic layer, aggregation of the copper occurred on the substrate surface rather than the formation of a uniform film.

Somewhat different results on the influence of imperfections in the substrate upon the mode of epitaxial growth were presented by W. J. Dunning and P. G. Fox (University of Bristol). They examined, with the optical microscope, the growth of ammonium iodide upon mica and observed a uniform epitaxial film spreading outwards until cleavage steps on the mica were reached and then a pyramidal form of growth of the iodide crystals was initiated. The importance of the substrate orientation upon kinetics of film growth was demonstrated clearly by the experiments of J. D. Lawless (University of Virginia), who had oxidized spherical single-crystals of copper in air and in copper sulphate solutions. Differences in the thickness of oxide film were shown by changes in the interference colours from different regions of the spherical surface. Examination by electron diffraction and electron microscopy showed differences in the preferred orientation of the polycrystalline oxide film on various zones of the single crystal.

The epitaxial growth of ice crystals on various substrates and its possible effect upon the formation of rain were discussed by B. J. Mason (Imperial College of Science and Technology, London). He described observations on the nucleation of ice on covellite which showed that after nucleation ice crystals may spread laterally on the surface without thickening. The experimental technique involved observing, with the optical microscope, the interference colours produced by the thin crystals on the cleaved covellite surface, and Dr. Mason illustrated his results with colour micrographs of kaleidoscopic variety.

Two further papers on electron diffraction studies of epitaxial growth were presented by M. Blackman (Imperial College of Science and Technology, London), who discussed the epitaxial polymorphism of thallium and cæsium halides, and H. Wilman (Imperial College), who gave some new examples of epitaxy. He showed many diffraction photographs illustrating the different forms of epitaxial growth on ionic, organic and metallic substrates of deposits condensed *in vacuo* or formed by chemical action.

A group of papers on the properties of surface films were presented next. J. A. Bennet (British Scientific Instrument Research Association) described an apparatus which enabled him to measure the electrical resistivity of a gold film as it was being deposited on either alumina or on a substrate of bismuth oxide on alumina. He found the resistivity decreased as the thickness of the film increased, an effect which he attributed to changes in continuity

of the film. This conclusion was in agreement with the results given by previous speakers, who showed that in the earliest stages of deposition an epitaxial film was not continuous.

The adhesion of evaporated metal films to glass was discussed by C. Weaver and P. Benjamin (Royal Technical College, Glasgow). The load required to leave a clear scratch through a metal coating deposited in vacuum on a glass substrate was measured and found to depend upon the time which had elapsed after deposition in the case of iron and aluminium, but not for gold. The adhesion of the gold could be attributed to Van der Waals forces, but the rapid increase in the adhesion and its greater value in the case of iron and aluminium could only be accounted for if some chemical bonding occurred between the glass and evaporated layer. Further experiments which tended to confirm that oxygen was necessary to produce this bonding were then described. An entirely different approach to the problems associated with deformation of evaporated layers on substrates was adopted by T. Evans (Tube Investments, Hinxton Hall). An oriented film of gold about 300 A. thick was evaporated on to a single crystal of silver, and on top of the gold film a polycrystalline film of carbon, platinum, iron or chromium was deposited. The composite specimen was then deformed. By dissolving away the silver a specimen thin enough to be examined directly by transmission in the electron microscope remained. This revealed that the presence of the polycrystalline layer modified the slip distribution in the substrate. Dr. Evans concluded that some of the effects could be attributed to adhesion between the polycrystalline and the gold layers.

The first section of the conference was completed by two papers on the surface tension of metallic interfaces. H. Mykura (University of Glasgow) showed that the shape of the grooves produced at grain boundaries when a metal surface is etched thermally depended upon the difference of orientation between the grains, while J. M. Blakely and H. Mykura (University of Glasgow) calculated how an exposed metal surface having a sinusoidal form would change its shape on heating by a process of self-diffusion leading to mass transport against curvature gradients.

Five papers were presented describing phenomena associated with solid – liquid interfaces. Prof. F. C. Frank (University of Bristol) discussed the kinematics of deposition and dissolution profiles of crystals and showed how the theory of kinematic waves was applicable to this study, while a review of phenomena at metal – electrolyte interfaces was given by R Parsons (University of Bristol), who summarized current ideas about the structure of the electrical double layer between a metal and an electrolyte.

The work of the J. Lucas research group on electrodeposition was introduced by M. J. Pick (University of Birmingham). After reviewing earlier work on electrodeposition he described their new investigations on the deposition of copper on single crystals and polycrystalline cube-texture copper. As in the case of vacuum deposition, the electro-deposited metal initially formed nuclei which eventually grew into each other, forming well-defined crystals. The shape of the nuclei was found to vary with the orientation of the substrate. Further aspects of the work of this research group were then presented by G. C. Storey, T. B. Vaughan and V. R. Howes (University of Birmingham). Changes in surface topography with changes in cathode orientation were determined by detailed light and electron optical examination, and the results obtained were explained in terms of bunching of the growth layers in the manner described in the earlier paper by Prof. Frank. A ciné film of deposits growing in a cell on the stage of an optical microscope were shown ; in one sequence growth by a spiral mechanism was clearly recorded.

Further experiments on the growth of electrodeposits of face-centred and body-centred cubic metals on single crystals of face-centred cubic substrates were described by H. Wilman and A. R. N. Reddy (Imperial College of Science and Technology, London). Examination of the deposits by electron diffraction showed that initially epitaxial growth occurred, but that in some cases this was accompanied by rotational disorientation.

The smoothing of electrode surfaces by anodic dissolution or cathodic deposition was discussed by J. Edwards (British Non-Ferrous Metals Research Association), who showed how the potential distribution, hence the rate of solution or deposition, was influenced by the topography of the electrode surface.

The papers on internal surfaces were introduced by J. Nutting (University of Cambridge). He outlined first the forms of internal surfaces thought to exist in pure metals, single-phase and two-phase alloys, and then discussed in more detail the structure of interphase interfaces. New results, obtained by transmission electron microscopy of thin metal foils, on the coherent interfaces found in aluminium alloys after suitable aging treatments were described, and the transition from coherent to partially coherent interfaces was shown to occur by the introduction of suitable structural dislocations.

The properties of grain boundaries are frequently discussed, but not often measured. An attempt to obtain quantitative information was described by G. M. Leak (British Iron and Steel Research Association, Sheffield), who showed how the dependence of temperature of the internal friction of iron could be related to its grain size. The relaxation time of the grain boundary damping was also found to be dependent upon alloy content, different results being obtained with interstitial and substitutional elements. P. B. Hirsch and M. J. Whelan (University of Cambridge) and R. Bullough (Associated Electrical Industries, Aldermaston) were more concerned with low-energy interfaces associated with deformation twins. Drs. Hirsch and Whelan described a mechanism for the formation of deformation twins and then discussed this in relation to the contrast effects obtained when examining thin metal foils of stainless steel in the electron microscope, while Dr. Bullough presented a theoretical treatment of the properties of structural dislocations and their movement during the extension of a twin interface.

A series of papers on the influence of interphase interfaces upon the mechanical properties of alloys were then presented. Experiments on the plastic deformation of aged aluminium–copper and aluminium–silver alloys were described by A. Kelly (University of Cambridge), who showed that after aging an aluminium–copper alloy to produce *G.P.* [1] zones the critical resolved shear stress at a given elongation was very sensitive to temperature, whereas after aging to produce *G.P.* [2] zones, or the spherical zones in aluminium–silver alloys, there was no thermally activated component. He deduced from these results that, with the aid of thermal fluctuations, dislocations could be made to pass through the narrow

G.P. [1] zones, but with the larger and thicker *G.P.* [2] zones thermal activation could never provide sufficient energy for the disruption of the zones. The mechanism of hardening in aluminium–copper alloys was discussed further by D. Dew-Hughes and W. D. Robertson (Yale University). They carried out tensile tests on single crystals of alloys which contained between 1 and 5 per cent copper and which had been aged at different temperatures and then used the results obtained to test the predictions of Orowan, Fisher Hart and Pry on the relationships between the shear stress and the particle spacing. The conclusion was reached that a modification of the Fisher Hart and Pry relationship gave agreement between the observed and calculated results. To account fully for the effects of aging upon the critical resolved shear stress, Dew-Hughes and Robertson derived the stresses required to force dislocations through the solid solution, then to pull them through the coherent strain fields surrounding the zones and finally to disrupt the zones. The sum of these three component stresses agreed closely with the observed shear stresses.

The conclusions of Kelly and of Dew-Hughes and Robertson on the modes of dislocation precipitate interactions were supported by the results presented by G. Thomas and R. B. Nicholson (University of Cambridge). They examined in the electron microscope thin foils of suitably aged aluminium alloys and observed how the dislocations interacted with coherent, partially coherent and incoherent precipitates. Clear evidence for the passage of dislocations through coherent and partially coherent precipitates was presented. But there was little evidence for the dislocation loops forming around precipitate particles as predicted by Fisher Hart and Pry. Further results on precipitate – dislocation interaction were given by E. Smith (Associated Electrical Industries, Aldermaston), who described the effects of hydride precipitates upon the plastic deformation of titanium and showed how the reversible twinning found in pure titanium was hindered by the hydride precipitates. Under conditions of rapid loading cracks developed from the interface between the hydride and the hindered twin.

The generation of dislocations at incoherent interfaces was discussed by J. W. Mitchell and A. S. Parasnis (University of Bristol). They showed how, in a dispersion of glass spheres in silver chloride, the stresses developed at interfaces due to differences in thermal contraction of the two phases could lead to the formation of dislocations by a process of prismatic punching. Optical micrographs were shown of the dislocation loops and their spatial distribution within the silver chloride matrix. Another function of interfaces, as a source of vacancies, was demonstrated by R. S. Barnes (Atomic Energy Research Establishment, Harwell) and Prof. A. H. Cottrell (University of Cambridge), who had investigated the effects associated with the annealing of radiation damage in copper produced by bombardment with α-particles. They found small bubbles were produced on annealing and reasoned that these were formed by the diffusion and aggregation of vacancies from either the nearest free surface or internal surfaces such as large-angle grain boundaries; convincing proof that twin interfaces did not act as sources for vacancies was produced. The influence of curvature on the energy of incoherent interfaces was illustrated by a film presented by G. Thomas and M. J. Whelan (University of Cambridge). Thin foils of an aluminium – 4 per cent copper alloy were aged at temperatures between 350° and 450° C. on a heating stage in the electron microscope while the structural changes as observed on the fluorescent screen of the microscope were recorded with a ciné camera. The nucleation and growth of the θ phase was clearly revealed together with the subsequent growth of the larger particles at the expense of the smaller ones.

From the conference it appeared that at the present stage of development the physicists and metallurgists had more to offer than the physical chemists towards our understanding of interfacial phenomena. The advances made since the introduction of electron diffraction techniques for the study of surfaces have been very great, but with the advent of the electron microscope into this field of study a much more detailed investigation of surface morphology has become possible. The explanation of why diffraction patterns could be obtained from deposits of less than one atom mean thickness has now been found, but it is still difficult to account for the preferential formation of epitaxial nuclei at lattice defects. Perhaps it is here that the physical chemists can be of help.

J. NUTTING

THE COLOMBO PLAN

ANNUAL REPORT

THE seventh annual report of the Consultative Committee for the Colombo Plan for Co-operative Economic Development in South and South-East Asia, which by agreement at the Singapore meeting of the Committee in October 1955 has been extended from July 1957 to June 30, 1961, is the last to appear before the future of the Plan is again considered at its 1959 meeting in Indonesia. The present report*, which covers the year 1957–58, records continuing increase in industrial production in the area as a whole, but in India the rate of expansion dropped from 8 per cent in 1956–57 to 1·5 per cent, which, however, accounted for most of the 13 per cent increase in output of electric power. Since 1950 training has been given to more than 15,500 trainees from countries in the area, and the services of nearly 8,000 experts provided by members of the Colombo Plan and by agencies of the United Nations. During 1957 expenditure on technical assistance under the Colombo Plan Technical Co-operation Scheme increased to about £3 million, reaching a total of £9·78 million since 1950, and during the first six months of 1958 it reached 3·9 million dollars.

Almost half of this expenditure has been for the provision of study and training courses, about a quarter for the supply of experts and the remainder on technical equipment. By the end of June 1958 expenditure on technical equipment reached a total of £2·35 million, and the number of scholarships and training awards granted by member countries totalled 6,952, an increase of 1,330 on the previous year.

* The Colombo Plan for Co-operative Economic Development in South and South-East Asia—Seventh Annual Report of the Consultative Committee, Seattle, Washington, November 1958. Pp. 192. (Cmnd. 610.) (London: H.M. Stationery Office, 1958.) 8s. net.

There were then 2,091 trainees taking courses in member countries. During the year there were 221 technical experts in the field compared with 207 in the previous year, making a total of 1,002 since the Plan began. The number of experts supplied in medical and health fields dropped sharply, but the number of engineering experts increased, and the number of those in food, agriculture and forestry and in transport and communications continued to increase.

Outside the Technical Co-operation Scheme, the United States, which has already provided, since the inception of the Plan, almost 4,000 million dollars in economic and technical assistance to Colombo Plan countries, continued to provide large-scale technical assistance. About 1,500 trainees were received in the United States and 543 trainees undertook instructional courses with United States assistance in the Colombo Plan area, while on July 1, 1958, about 2,000 United States technicians were on duty in Colombo Plan countries. Under the Mutual Security Programme and the President's Fund for Asian Economic Development, 408 million dollars were made available to Colombo Plan countries during the year, and finance was provided for a Radio-isotope Centre in Burma, including arrangements to train Burmese in nuclear techniques in the United States. Laboratory equipment was provided for a course in nuclear physics at the University of the Philippines, and scientists from the Philippines and Thailand are being trained in the United States.

During the year, fewer new Colombo Plan scholarships and training awards were granted, partly because of the pressure on existing training institutions but partly also because of the marked increase in the number of long-term awards. The establishment and development of training facilities within the area accelerated and 20 per cent of the training awards under the Technical Co-operation Scheme are now provided within the area. Looking to the future, the report again stresses the need to ensure that technical and managerial skills are developed at a rate sufficient to permit the effective use of capital and other available resources. The technical ability of the population must keep pace with the expansion of development and it is now urged that the less-developed countries give greater attention to the development of human skills required for the effective and appropriate utilization of resources. Finally, stress is laid both on the value of co-operation and of the more rapid development of technical training facilities within the area.

BEAR ISLAND COD

DURING the summer, shoals of cod, consisting mainly of immature individuals, move into feeding grounds off Bear Island near Spitsbergen. These concentrations form an important fishery resource, and for the past ten years, part of the work of the Fisheries Laboratory, Lowestoft, has been to trace the migrations that lead to this shoaling behaviour.

In doing this work*, Mr. G. C. Trout has been greatly helped by discovering that these cod have two main kinds of otoliths, which he calls split-zone and opaque-zone types. Both kinds are found in roughly equal proportions on the more southerly grounds, but with increasing distance from Bear Island the two tend to become segregated. This and other evidence suggested that the shoals advancing on Bear Island separate into two groups, one moving north-eastwards in the direction of Hope Island and the other northwards to Spitsbergen. Tagging experiments carried out during 1951 and 1952 were in keeping with this hypothesis and showed that in late autumn the fish returned to winter quarters in the Bear Island area.

Trout suggests that these facts and others are consistent with the general idea that the annual migratory cycle of the Barents Sea cod populations is closely linked with the movements of the water masses. During their summer migrations the feeding cod are partly pelagic in habit (due to daily vertical migrations in response to light conditions) and may thus drift northwards in the West Spitsbergen current or in a branch of the North Atlantic drift. The return migration in winter is against the current and takes place along the bottom in the absence of light (and the lack of daily vertical movement in the fish). The distribution of the cod is thus seen to be "... the resultant of interaction of changing behaviour with the cycle of movement of the water masses in which the cod are found".

This would seem to be a useful working hypothesis. Perhaps it will prove to be partly right, but the fact that it can be posed at all is a measure of the work being undertaken by the Fisheries Laboratory at Lowestoft.

N. B. MARSHALL

* The Bear Island Cod: Migrations and Movements. By G. C. Trout. Fishery Investigations, Series II, Vol. 21, No. 6. Pp. 51. (London: H.M. Stationery Office, 1957.) 16s.

PROGRESS IN BRITISH FORESTRY

THE thirty-eighth annual report of the Forestry Commissioners for the year ending September 30, 1957*, reviews both the record of work accomplished in Britain and the national situation in relation to policy and programmes adopted by the Government. The record as a whole must be accepted as quite satisfactory, with encouraging features indicating that some at least of long-standing difficulties are being overcome, even if others, such as that of acquiring land for afforestation, have definitely held up progress in planting work. Criticism has been made in the past that not enough was being done to get the productivity of the privately owned woodlands—still the greater proportion over the country as a whole and still far from having recovered from the onslaught of two world wars—restored and brought up to the levels possible with skilled management. The rate of planting by private owners has nearly doubled in the past five years and has increased by as much as 4,500 acres in 1956–57, compensating for a drop of the same order in the State's own total. This increase is significant as revealing a changed situation which has been widely discussed, both in

* Thirty-eighth Annual Report of the Forestry Commissioners for the year ended 30th September, 1957. Pp. 90+4 plates. (London: H.M. Stationery Office, 1958.) 5s. 6d. net.

Parliament and among foresters, and one to which the Zuckerman Report also directed attention.

The national policy since the end of the First World War has been to build up a stock of standing timber estimated to be adequate to make Great Britain independent of imports of wood over an emergency lasting about five years, and the question is naturally being asked whether, with the changed conditions now prevailing, we should still continue to retain the same target of 5 million acres of productive forest. Although it can be demonstrated that there is still enough suitable land, there are practical difficulties in acquiring it, and, of course, afforestation implies a large capital investment at a time when there are innumerable demands for capital. Forestry is unquestionably becoming more attractive to the private investor despite the current drop in prices, while the Government is also tending to place the emphasis on the economic and social benefits of forestry rather than on the earlier strategic reasons.

An important factor is certainly that more and more of the new forests in Britain are coming into production, often large-scale production, and it is obvious that the annual output is going to rise steadily for as many years to come as we have maintained a large planting programme. Not only is this giving more and more local employment, but also one centre after another is seeing new industrial units open up, or existing ones expanding: in the year under report, this has happened in Flintshire, Lancashire, Dumfriesshire and Monmouthshire, and this is clearly only a beginning. It is noteworthy, too, that 400 miles of new roads have been completed, with 313 more under construction, reducing the inaccessibility to modern amenities that has hitherto contributed so much to rural depopulation. The only other feature of this report which can be referred to here is the attention given to developing the social aspects of forestry, particularly in connexion with the national forestry parks, which all record very significant increases in the numbers of visitors and for which an excellent series of small guides has been issued. The special importance of awakening an interest in forestry among the rising generation is receiving recognition in the form of the provision of facilities in the forests for schools and for colleges for the training of teachers. H. G. CHAMPION

FORMATION OF ABERRANT CELL WALLS AND OF SPORES BY THE GROWING YEAST PROTOPLAST

By A. A. EDDY* and D. H. WILLIAMSON
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THE so-called protoplasts which have been isolated by exposing various micro-organisms to conditions favouring dissolution of the cell wall may be placed in two main categories depending on their *ability* or *inability* to reform a normal cell wall on cultivation and thereby to revert directly to cells of the parent type[1]. Work in these laboratories with protoplast-like bodies released from yeast by the action of gut-juice from *Helix pomatia*[2] has now brought to light the interesting situation that, whereas they have never been observed directly to revert to whole cells, they nevertheless are capable of giving rise to a superficial membrane which, to some extent, resembles the normal wall of the yeast cell. However,

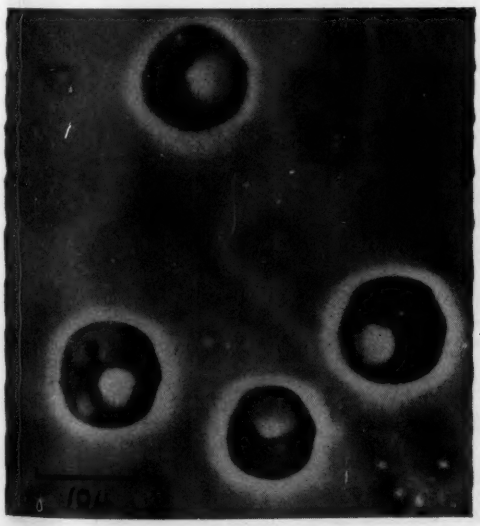

Fig. 1. Freshly isolated protoplasts

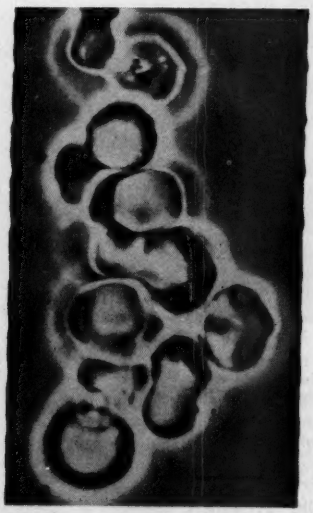

Fig. 2. Protoplasts suspended for 2 hr. at 25° C. in malt extract medium (ref. 3) containing 10 per cent (w/v) glucose

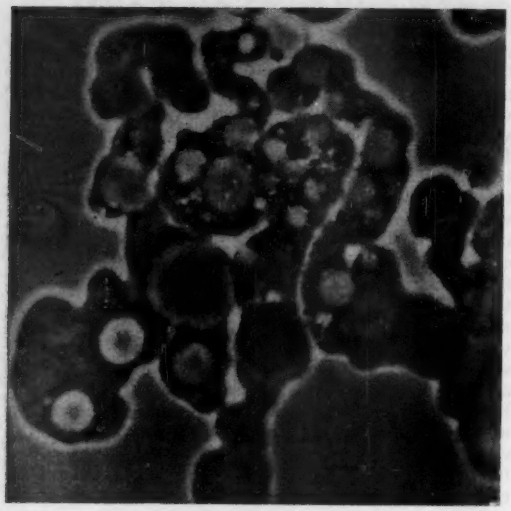

Fig. 3. Protoplasts after incubation for 40 hr. at 25° C. on solid malt extract medium (ref. 3) containing 10 per cent (w/v) mannitol

conditions have been found which induce the protoplasts to form spores from which whole cells may arise on germination, the process thus providing an indirect means of effecting reversion to the normal state.

The method of isolating protoplasts was modified from that previously described[2]: (1) by using mannitol as an osmotic stabilizer instead of rhamnose; (2) by effecting solution of the wall at 30° C. rather than at 25° C.; (3) by using 5 mgm./ml. instead of 1 mgm./ml. of snail enzyme. Under these conditions, more than 90 per cent of the cells of *Saccharomyces carlsbergensis* (National Collection of Yeast Cultures, strain 74) were converted into protoplasts in 2–3 hr., the product containing not more than 0·1 per cent viable whole cells as determined by plating it on a solid medium lacking mannitol.

Samples of protoplasts (10^7–10^8/ml., final concentration) were transferred to a series of nutrient media which were either based on malt extract[3] or were of the synthetic type[4]. The media were supplemented with either mannitol, glucose, maltose or sucrose at selected concentrations equivalent to osmotic pressures of 10–20 atm. When malt-extract was used, aureomycin (20 μgm./ml.) was included to suppress growth of bacteria. Examination of samples withdrawn at intervals from cultures variously held at 18–30° C. for periods of up to 2 weeks revealed that the protoplasts underwent a sequence of striking changes in appearance. For example, 1–2 hr. after transfer to a complete growth medium, the surfaces of the protoplasts displayed irregular local swellings (Figs. 1 and 2) which, during a subsequent 30 hr., tended to develop into massive irregularly shaped outgrowths (Fig. 3), the protoplasts themselves increasing 5–50 fold in volume. That a form of growth was involved in these changes was readily demonstrated by showing that the respective contents of protein, ribonucleic acid and insoluble anthrone-positive carbohydrate, determined by conventional methods, increased several-fold during the first few hours.

The way in which swelling of the growing protoplasts occurred suggested the presence of a fairly rigid membrane defining the outline of the cell at each stage of growth. In fact, such membranes

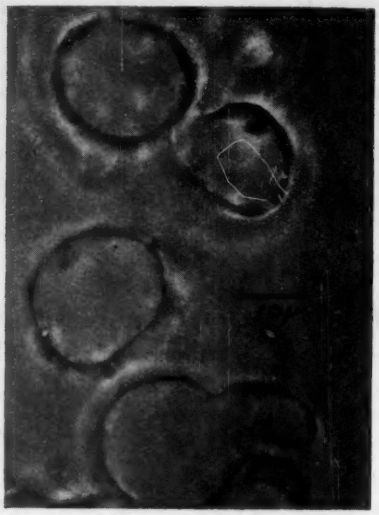

Fig. 4*a*. Aberrant cell walls (phase contrast)

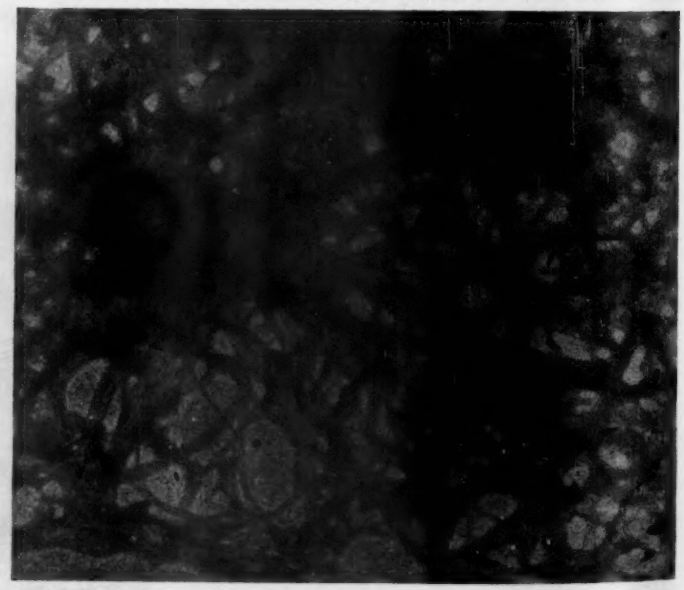

Fig. 4*b*. Aberrant cell walls (unshadowed electron micrograph)

Fig. 4c. Aberrant cell walls (shadowed electron micrograph)

were present and could readily be detected on adding an excess of water (10 vol.), which caused the contents of the protoplasts to disperse while the outer envelopes were preserved. No trace of the membranes was found, however, when freshly isolated protoplasts were lysed in this way.

In order to examine them further, the membranes released by lysis were centrifuged at 1,000*g* for 5 min. and washed with water. They were then shaken for 10 min. with fine glass beads in a Mickle disintegrator in order to remove adhering debris, and recovered once more by centrifugation. The form and fine structure of the membranes are illustrated in Fig. 4*a*, *b* and *c* (electron micrographs obtained by courtesy of Metropolitan Vickers, Ltd.), respectively, while their composition is contrasted in Table 1 with that of normal walls derived from the same strain of yeast.

A striking feature of the composition of the material comprising the aberrant walls is its relative deficiency in amino-acid residues, most of the nitrogen content, in fact, being accounted for as N-acetylglucosamine. This circumstance may be attributed to the absence from the surface of the protoplast of a specific protein template which, in the case of the intact cell, plays a direct part in the synthesis of new cell wall material. In these terms, the aberrant walls can perhaps be regarded as representing part of the basic structure of the normal wall.

The results obtained on culturing the protoplasts in synthetic medium deficient in available nitrogen were quite different from those described above in that little or no irregular

Table 1. Comparison of Cell Walls produced by the Protoplast with those from the Parent Yeast

	Nitrogen (per cent dry wt.)	Phosphorus (per cent dry wt.)	N-acetyl glucosamine* (per cent dry wt.)	Invertase† (μmole sucrose/mgm. wall/hr.)
Normal cell wall	1·0	0·19	0·9	6
Protoplast wall**	2·2–2·7	0·03	27–33	< 0·03

	Amino-acids	Mannose‡	Glucose‡	Anthrone-positive§ carbohydrate (per cent dry wt.)
Normal cell wall	+++	+	++	55
Protoplast wall**	±	+	++	35–45

* Determined after hydrolysis for 72 hr. with two successive portions of snail enzyme (ref. 7).

† Measured at 25° C. in presence of 0·01 *M* acetate buffer, *p*H 5·3. Activity of normal walls was shown to be twenty times greater than could be accounted for by the proportion of whole cells present.

‡ Found after hydrolysis with sulphuric acid (70 per cent v/v) for 2 hr. (ref. 7).

§ Calculated as glucose equivalent.

** Values refer to three independent preparations.

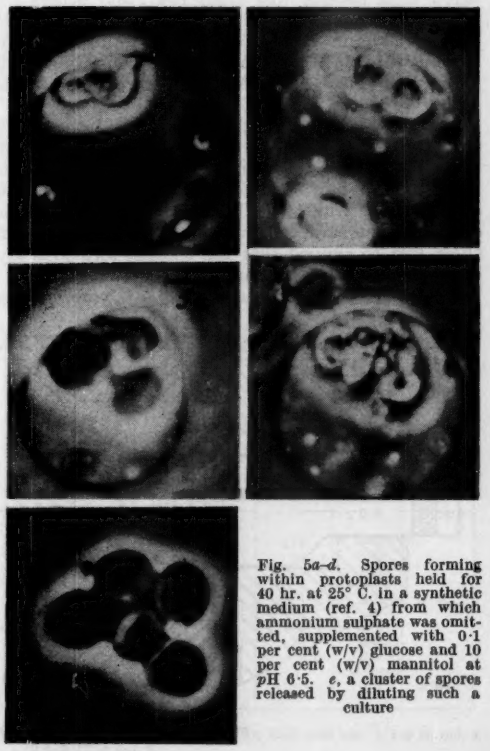

Fig. 5*a–d*. Spores forming within protoplasts held for 40 hr. at 25° C. in a synthetic medium (ref. 4) from which ammonium sulphate was omitted, supplemented with 0·1 per cent (w/v) glucose and 10 per cent (w/v) mannitol at *p*H 6·5. *e*, a cluster of spores released by diluting such a culture

swelling of the protoplasts occurred. They tended instead to develop a large main vacuole at the perimeter of which, and still within the protoplast itself, a cluster of 2–5 highly refractile spherical bodies each of about 3μ diameter could be discerned (Fig. 5). The appearance of these refractile bodies, their ability to develop into mixtures of haploid and diploid cells on being transferred to nutrient media of low osmotic pressure, as well as their reaction to the spore stain of Bouthilet[5], strongly suggested that they were, in fact, spores in various stages of development. In this connexion, it may be significant that culture of the parent yeast itself in a similar nitrogen-deficient medium also resulted in a good yield of ascospores being obtained.

It is stressed that throughout this work no evidence was obtained that the yeast protoplasts were able to produce intact cells other than through spores as an intermediate stage. This conclusion is apparently at variance with the work of Nečas[6], who claimed to have observed direct development of yeast cells from protoplast-like bodies originally obtained from a spontaneously lysing yeast. While this author seems to have encountered material such as that illustrated in Fig. 3, he apparently failed to detect development of aberrant cell walls. It is interesting to speculate that, under the conditions employed by Nečas, spores may have been formed and have germinated so rapidly that their presence was not detected. In this connexion it may be significant that Nečas found regenerated yeast cells to differ both among themselves and from the parent strain, an observation which would be compatible with their having *originated* from different spore segregants.

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CÆSIUM-137 IN SWEDISH MILK AND SOIL

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THE cæsium-137 content of dried milk from mid-Sweden and in soils from different locations has been determined by γ-spectrometric methods. One dried milk sample was from 1947, the others from 1955–58 (kindly provided by Svenska Mjölkprodukter AB, Stockholm). The soils were sampled in the summer of 1957. Three samples, consisting of the layers 0–2·5, 2·5–5 and 5–10 cm. were taken at each place.

Cæsium-137 was determined directly by γ-spectrometry without chemical separation. The detector was a 4 in. × 4 in. sodium iodide (thallium) crystal, made by Harshaw Chemical Co., with copper housing and 'Pyrex' window. To get a high geometrical efficiency the sample container made of thin copper sheet was so shaped that the sample formed a layer of uniform thickness around the crystal (cf. Fig. 1). The volume of the container was 0·7 l., corresponding to about 500 gm. dried milk and 600–1,000 gm. soil. The detector unit was surrounded by a 10-cm. lead shield. The pulse analyser was of the Hutchinson-Scarrot type with 70 channels and was used with a channel-width of 25 keV.

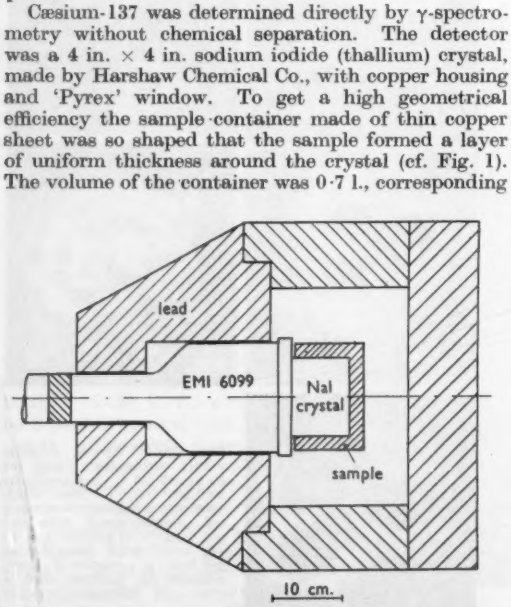

Fig. 1

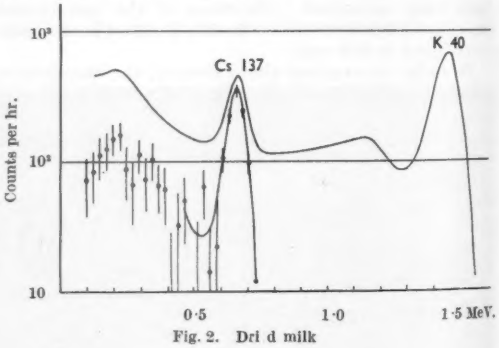

Fig. 2. Dri d milk

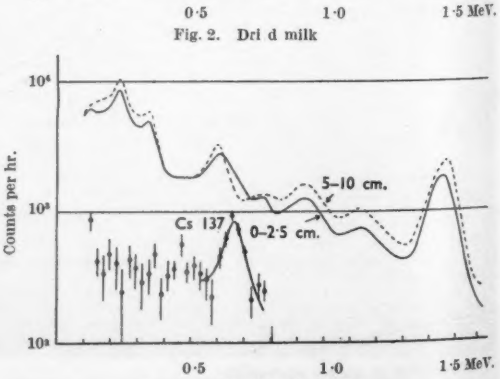

Fig. 3. Soil No. 4

Table 1. Cæsium-137 and Strontium-90 in Milk

(1) No.	(2) Date of manufacture	(3) pc. Cs-137/gm. K	(4) pc. Cs-137/l. milk	(5) pc. Sr-90/gm. Ca	(6) pc. Sr-90/l. milk	(3)/(5)	(4)/(6)
1 W*	28.8.47	< 1	—	< 0·14	—	—	—
2 W	29.11.55	17·0	27	2·50	2·7	6·8	10·2
3 S	14.2.56	12·1	20	1·70	1·9	7·1	10·6
4 W	24.4.56	12·2	18	1·98	2·1	6·2	8·8
5 W	22.10.56	28·3	42	4·32	4·5	6·6	9·3
6 W	6.1.57	17·0	26	3·37	3·6	5·1	7·1
7 S	1.6.57	18·8	26	4·54	4·1	4·1	6·3
8 W	21.6.57	22·1	34	3·87	4·0	5·7	8·4
9 S	15.9.57	53·1	77	6·37	7·3	8·3	10·6
10 W	13.12.57	22·4	33	4·88	5·3	4·6	6·2
11 S	21.1.58	22·6	37	4·47	5·2	5·1	7·1
					Mean	6·0	8·5

* W, whole milk; S, skimmed milk. The estimated errors are: col. 3, ± 1; col. 5, ± 0·1.

The only detectable γ-activity in the milk was due to cæsium-137 and potassium-40. A typical γ-spectrum of dried milk is shown in Fig. 2. The absolute efficiencies and the shape of the spectra of these activities were determined by measuring milk samples with known amounts of cæsium-137 and potassium added. The lower curve in Fig. 2 was obtained by subtracting the potassium contribution, determined from the 1·45-MeV. photopeak. The shape of this curve fits well with the cæsium-137 spectrum determined in the calibration. A counting time of 2 hr. gives a statistical error of 5–10 per cent in the determination of cæsium at the present levels of milk activity (~ 20 pc./gm. potassium).

In the soils, the cæsium-137 activity could not be determined directly because of the radium and thorium content. In particular, the 0·61-MeV. line due to radium C, which is of high intensity and is close to the 0·66-MeV. line due to cæsium-137, interferes.

There is reason for believing that the cæsium-137 content in the 5–10 cm. layer is much lower than that in the upper layers, whereas the composition of the natural activity (thorium, radium, potassium) might be about the same for the three layers. Thus it would be possible to determine cæsium-137 from the difference in γ-spectra between a top layer and the bottom layer. In Fig. 3 the γ-spectra from the 0–2·5-cm. and 5–10 cm. layers of one soil are given. Above 0·8 MeV. the shapes of the spectra are the same within the statistical errors, indicating that the relative amounts of the components of the natural activity are the same. By normalizing the spectrum of the bottom layer to give the same intensity above 0·8 MeV. as the upper layer and subtracting it from the latter, a residue was obtained mainly consisting of a well-resolved cæsium-137 peak. Clearly, the amount of cæsium-137 in the bottom layer must be very small compared with the upper layer if this method is to give the true content of cæsium-137. The known behaviour of cæsium tracer in soils[1] indicates that this assumption is justified. The same calibration as for dried milk was used, because the difference in density and composition between soil and dried milk is estimated to be of small importance with the present geometry. With a counting time of 1 hr. the error in the cæsium-137 determination is estimated to be ± 40 pc./kgm. soil at the present low levels of activity.

Table 2. Soil Types and Precipitation-rates

No.	Location	Type of soil	Yearly precipitation-rate (mm.) Mean 1955–57
1	Skarhult 55·9° N., 13·3° E.	Moraine loam	570
2	Fröslida 56·8° N., 13·0° E.	Fine sand	1,180
3	Uituna 59·8° N., 17·7° E.	Heavy clay	530
4	Offer 63·0° N., 18·0° E.	Silty clay loam	500

Measurements on soils sampled during the summer of 1958 were started in August 1958. In this case the main γ-activity in the top layer is due to zirconium + niobium-95 (0·75 MeV.) in fall-out during the first half of 1958. It is estimated that a determination of cæsium-137 for these soils will be possible in 1959, when the zirconium + niobium-95 has decayed sufficiently.

(*a*) *Milk*. The results are given in Table 1. For comparison the content of strontium-90, determined radiochemically by S. Häggroth[2], is also given. As is to be expected, the sample from 1947 contains no detectable cæsium-137 or strontium-90 activity. It is not possible with the present material to find any trend as regards the variation with time in the other values. The correlation between cæsium-137 and strontium-90 is, however, quite good. Assuming a linear dependence, the coefficients of correlation are 0·84 and 0·91 for columns 2–5 and 4–6 respectively.

(*b*) *Soil*. Some characteristics of the soils are given in Table 2 and the results are summarized in Table 3. The amounts of activity seem to be in reasonable agreement with measurements of activity

Table 3. Cæsium-137 and Strontium-90 in Soils

(1) Soil No.	(2) Layer	(3) pc. Cs-137/ kgm. soil	(4) mc. Cs-137/ km.²	(5) pc. Sr-90/ kgm. soil	(6) mc. Sr-90/ km.²	(4)/(6)
1	0–2·5	1,450	35·9	574	14·2	
	2·5–5	126	3·5	66	1·8	
	5–10	0*		18	1·1	
			39·4		17·1	2·30
2	0–2·5	574	15·9	210	5·8	
	2·5–5	125	3·3	74	2·0	
	5–10	0*		22	1·2	
			19·2		9·0	2·14
3	0–2·5	447	12·5	216	6·0	
	2·5–5	0	0·0	57	2·0	
	5–10	0*		16	1·0	
			12·5		9·0	1·40
4	0–2·5	570	13·1	202	4·7	
	2·5–5	0	0·0	22	0·5	
	5–10	0*		4·5	0·3	
			13·1		5·5	2·38

* Assumed value.
The estimated errors of the sums for each soil are ± 1·5 in col. 4 and ± (0·1–0·3) in col. 6.

in precipitation[3]. A detailed comparison is not possible until more extensive material is available. The ratio cæsium/strontium is in fair agreement with measurements made by N. G. Stewart *et al.*[4].

The results indicate that there is a good correlation between the cæsium-137 and strontium-90 values not only in soils, where it is to be expected, but also in milk. It is of course quite probable that regions with different climatic and agricultural conditions will give milk with different ratios of cæsium-137 to strontium-90, but within each region it seems possible to use the cæsium-137 values for an estimation of the strontium-90 content, provided that the contamination is due to atomic bomb debris. As the determination of cæsium-137 is far more rapid than the radiochemical determination of strontium-90, this would have practical advantages.

As regards the soils, the direct determination of cæsium is of special value, as the present radiochemical methods for the determination of strontium-90 mostly involve an extraction of the soil, the efficiency of which it is extremely difficult to determine.

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HAIR RECEPTORS IN LOCUSTS

Hair Plates on the First Cervical Sclerites of the Orthoptera

MITTELSTAEDT[1] has described four pairs of hair plates in the neck of the dragonfly, *Anax imperator*, which register movement of the head relative to the body. A pair of hair plates found in the neck of the locusts *Schistocerca gregaria* and *Locusta migratoria migratorioides* (Fig. 1) has been shown to fulfil a similar function. The tip of the first cervical sclerite on each side of the neck bears an oval swelling covered with fine hairs (Fig. 2) at the point where it forms a ball-and-socket joint with the post-occipital condyle of the head. Several types of head movement, in particular rotation of the head relative to the long axis of the body, deflect these hairs and also some, at least, of the hairs on the anterior edge of the prothorax. The hair plate is

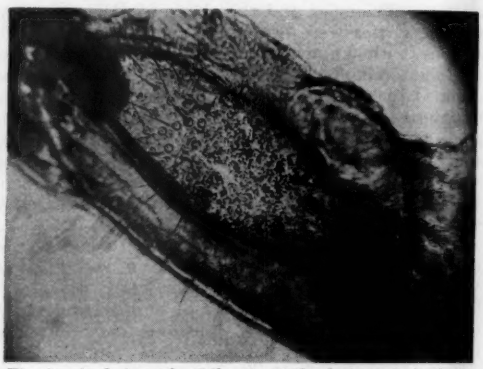

Fig. 2. A photograph of the tip of the first cervical sclerite, showing the oval swelling of the hair plate bearing many fine hairs

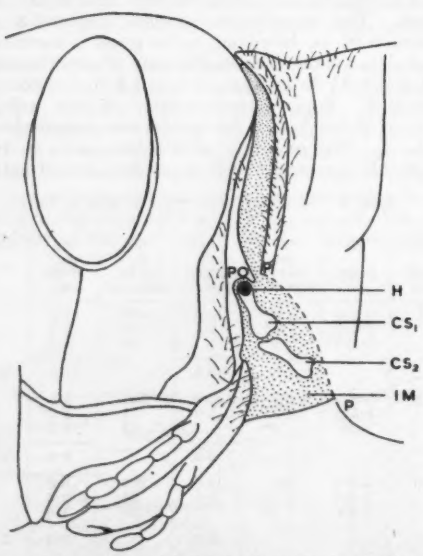

Fig. 1. Diagram of part of the head and prothorax of *Schistocerca gregaria* with the head pulled slightly to one side to reveal the intersegmental membrane, cervical sclerites and hair plate. Some of the hairs present on the prothorax and head are also shown. *P–P*, pronotum cut away to reveal the cervical sclerites; CS_1, CS_2, first and second cervical sclerites; the second sclerite articulates with the region of the pronotum that has been removed; *H*, hair plate; *PO*, post-occipital region of the head; *IM*, intersegmental membrane

innervated by a branch of the second pair of nerves from the first thoracic ganglion; a second branch of this nerve runs up to the anterior edge of the prothorax.

Laboratory studies with flying locusts have demonstrated that *Schistocerca* and *Locusta* show a dorsal light reaction, similar to that shown by *Anax*, turning about the longitudinal axis until the greatest light-intensity falls on the dorsal ommatidia, then continuing to fly in this position. The head is turned until the dorsal ommatidia are perpendicular to the light source and the body is then rotated to be aligned with the head. The ability of the locust to remain thus orientated is reduced if all the hairs on the anterior edge of the prothorax are destroyed, and it is extremely difficult for it to do so if the hair plates are destroyed. If both the hair plates and the prothoracic hairs are destroyed the locust still rotates until the dorsal ommatidia are perpendicular to the light source but is completely unable to remain orientated in this position because the body cannot be maintained in the correct angular position relative to the head. The hair plates, and to a lesser extent some of the prothoracic hairs, function as proprioceptors registering relative head and body movement.

Hair plates have been found on the first cervical sclerites of representatives of all the main families of Saltatoria. They are present in flightless subterranean species such as *Gryllotalpa gryllotalpa* and *Cylindracheta* sp., in brachypterous species like

Pholidoptera griseoaptera, and in wingless forms such as *Lentula callani*, as well as in alate species such as *Chorthippus brunneus*. They are well developed in nymphs as well as adults and it seems likely that they have a similar proprioceptive function throughout the order.

This work was carried out during the tenure of a Senior Research Award from the Anti-Locust Research Centre, London.

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[1] Mittelstaedt, H., *Z. vergl. Physiol.*, **32**, 422 (1950).

Function of certain Prothoracic Hair Receptors in the Desert Locust

The behavioural experiments of Goodman (previous communication) suggest that registration of displacement of the head relative to the body—particularly rotational movement—in *Schistocerca gregaria* is carried out at least in part by external proprioceptors, consisting of hair sensillæ on the cervical hair plates and on the anterior edge of the pronotum. This view would be corroborated if the responses of the hairs were found to be those typical of other insect hair proprioceptors, such as those described by Pumphrey[1] and Pringle[2].

Attempts were therefore made to record the electrical discharges in the nerves supplying these hair receptors while the latter were stimulated with a mechanically controlled glass needle. The hairs are innervated by branches of the second nerve of the first thoracic ganglion; using fine platinum wire electrodes and a high-impedance input d.c. amplifier, it proved impossible to record discharges in the nerves supplying the cervical hair plates, which were so fine that the necessary dissection either broke them or caused them to dry out rapidly. It was possible, however, to record discharges in the nerve supplying the hair sensillæ distributed along the anterior edge of the pronotum. A constant maintained deflexion of a single hair with a fine glass needle then produced a relatively high initial discharge frequency (200–300 impulses/sec.) which became adapted rather rapidly to a steady level of 40–50 impulses/sec., which was maintained for a long period (Fig. 1). The response was obtained to deflexion of the hairs in any direction and the initial frequency of discharge appeared to depend both on the speed and magnitude of the original deflexion; the adapted frequency, however, bore no relation to the magnitude of the deflexion, as Pumphrey[1] found in certain cockroach proprioceptors, and indeed this level was very similar in all preparations (Fig. 1). The hairs could be stimulated by gross air movements and also by pure tones in the range 100–500 c./s., if these were of sufficient intensity; in the latter case the response was synchronous with the stimulus frequency.

The responses described above are very similar to those found by Pumphrey[1] and Pringle[2] in certain insect hair sensillæ now agreed to be proprioceptors, and certainly fit the receptors for the role suggested for them by Goodman. The pronotal receptors on one side, up to the dorsal median line, are innervated by the nerve of that side; thus, with the two cervical hair plates, there are in all four hair beds, disposed in such a way that information about the equilibrium position and direction of rotation of the head relative to the body can be registered. It seems likely that the cervical plates register the equilibrium position, while the prothoracic hairs register movement; this speculation is supported by Goodman's evidence that removal of the cervical plates makes the maintenance of an equilibrium position almost impossible, while removal of the prothoracic organs only partially reduced this ability.

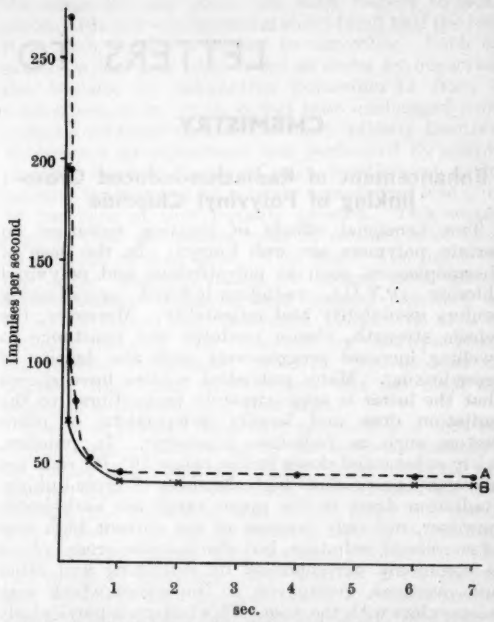

Fig. 1. Impulse frequency elicited by constant deflexion of single prothoracic hair receptor plotted against time after onset of stimulus; curve *A* resulted from a greater initial deflexion than for *B*

If the pronotal hair fringe is examined closely, it is found that it consists of a collar of upstanding, anteriorly sloped hairs which are only displaced by head movements in the dorso-ventral plane or by extreme angular rotations, and also a number of hairs on the underside of the edge of the pronotum which would appear to be displaced by any movement of the head relative to the body. Since the hairs in the collar-like fringe are deflected by wind when the locust is in flight, it would seem that proprioceptor functions in the air are carried out by the hairs under the edge of the pronotum. Histological preparations of the hairs (for which I am indebted to Miss K. M. Becker) show no apparent differentiation between the organs on the upper and under sides of the edge of the pronotum nor indeed from certain other, presumably tactile, hairs found elsewhere in the locust; the nerve fibre ending is apparently inserted at the centre of the hair, which accords with the fact that bending in any direction produces a response. This should be contrasted with the eccentric nerve insertion in campaniform sensillæ and in hairs responsive to bending only in one direction, noted by Pringle[3].

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Dec. 10.

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LETTERS TO THE EDITORS

CHEMISTRY

Enhancement of Radiation-induced Cross-linking of Polyvinyl Chloride

The beneficial effects of ionizing radiation on certain polymers are well known. In the case of thermoplastics, such as polyethylene and polyvinyl chloride (P.V.C.), radiation-induced cross-linking confers insolubility and infusibility. Moreover, the tensile strength, elastic modulus and resistance to swelling increase progressively with the density of cross-linking. Many published studies have shown that the latter is approximately proportional to the radiation dose and largely independent of other factors such as radiation intensity[1]. In practice, fairly substantial doses in the range 10^7–10^8 rads are necessary to produce high densities of cross-linking. Radiation doses in the upper range are undesirable however, not only because of the current high cost of sources of radiation, but also because cross-linking is commonly accompanied by dislinking and other side-reactions, giving rise to impurities which may accumulate with the dose. This feature is particularly troublesome with polyvinyl chloride, in which cross-linking is accompanied by dehydrochlorination and discoloration[2].

These difficulties were early realized and have led to a search for additives which would enhance the cross-linking reaction. A true sensitizer is one that would increase the primary yield of cross-links, that is to say, enhance the interaction of radiation with the polymer. Neither theory nor practice encourages confidence that such a sensitizer may emerge. It is known, however, that high densities of cross-linking result from low doses when there is a possibility of a chain-reaction, as in unsaturated polyesters[3]. There is no increase in yield of primary radicals, but several network junction points may be created for each initiating radical during the propagation reaction, and the density of cross-linking is no longer solely proportional to the radiation dose.

A chain reaction could also be exploited with normally saturated polymers, like polyvinyl chloride, if these could be induced to suffer chain-transfer with a suitable propagating monomer *in situ*, for each chain-transfer step could lead to an additional junction point on the polyvinyl chloride. Recent studies on the polymerization of allyl esters have shown that these have a short propagation chain-length due to degradative chain-transfer, but that this process is accompanied by effective chain-transfer[4]. Diallyl and triallyl esters, moreover, are readily available and are compatible with polyvinyl chloride.

The rate of polymerization of pure allyl esters under irradiation by electrons or by γ-rays was found to be very low, compared with vinyl esters (Pinner, S. H., and Wycherley, V., unpublished work). The presence of polyethylene had little influence on the rate of conversion, but in the presence of polyvinyl chloride an extraordinary increase in conversion rates was observed over certain regions of composition.

This encouraged an examination of the products resulting from the irradiation of solid solutions of polyvinyl chloride in diallyl and triallyl esters, when they were found to exhibit the properties associated with a very high density of cross-linking. In Fig. 1, the swelling index (ratio of specimen weight after 24 hr. swelling in tetrahydrofuran at 20° C. to initial weight) is shown for solid solutions of polyvinyl chloride in a diallyl ester (open circles) and in a triallyl ester (solid circles) as a function of radiation dose, in comparison with the swelling index of unplasticized polyvinyl chloride 'Cobex' (square). The enhanced cross-linking of the polyvinyl chloride is further evident from the curves in Fig. 2, showing the tensile strength at 100° C. as a function of radiation dose for solid solutions of polyvinyl chloride in a saturated ester (crosses), in a diallyl ester (half-solid circles), and a triallyl ester (open circles) in comparison with the behaviour of 'Cobex' (solid circles).

A preliminary kinetic analysis of the rates of conversion of the allyl esters as a function of their concentration has indicated the inadequacy of a simple energy-transfer mechanism to explain the results. Coupled with the enhanced density of cross-linking of the polyvinyl chloride, the analysis suggests interaction of the polymer chains, not only with the propagating allyl radicals ($R.CH_2$—$\dot{C}H$—CH_2O—) but also with the resonance-stabilized allylic radicals (CH_2=CH—$\dot{C}H$—O—). Reactivation of allylic radicals has been previously proposed to account for increased allyl polymerization rates at very high pressures[5].

The difference in behaviour between polyvinyl chloride and polyethylene may be attributed to the greater ease of abstraction of atoms from the chlorinated polymers, though questions of compatibility of the ester may also be involved. The efficacy of allyl esters probably arises from the short propagation chain-length and the accumulation of stabilized radicals, which renders the action of these monomers quite distinct from that of vinyl monomers, which

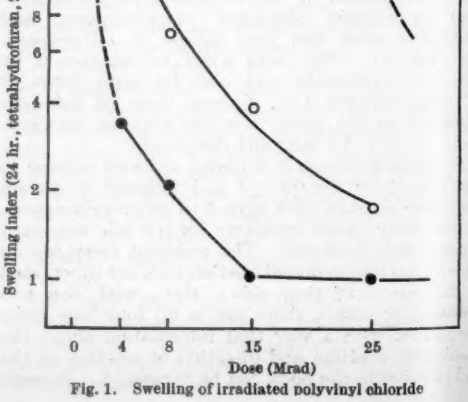

Fig. 1. Swelling of irradiated polyvinyl chloride

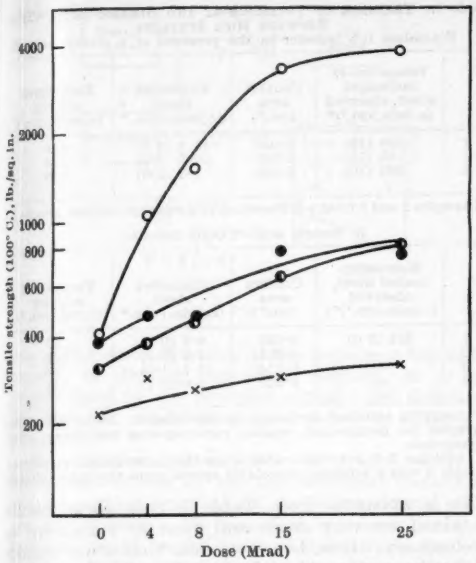

Fig. 2. Tensile strength of irradiated polyvinyl chloride

are also known to be polymerized *in situ* but without comparable involvement with the parent polymer.

Since highly cross-linked vinyl chloride copolymers are thus made readily available through the agency of allyl esters, it seems possible to regard these as 'promotors' for radiation-induced cross-linking, operating by a process of 'secondary initiation' (to distinguish it from primary initiation by the incident radiation) and giving a density of cross-linking much higher than that obtainable by radiation alone.

The kinetic data and theoretical implications of this work will be presented in greater detail in forthcoming publications.

I wish to thank Prof. A. Charlesby for his early interest and encouragement and colleagues at Hinxton Hall for discussions and experimental assistance. Part of this work was carried out in collaboration with B.X. Plastics, Ltd., and I thank the Chairman of B.X. Plastics, Ltd., and the Chairman of Tube Investments, Ltd., for permission to publish this account.

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March 2.

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Adhesion and Ion-Exchange between Mica Surfaces

If the adhesive forces between mica surfaces[1] are due to ionic interactions as has been suggested[2], interchange of ions between two mica surfaces brought into contact might be expected. If matching of ions and sites in the aluminosilicate lattice were complete, we should find a redistribution of the surface ions between the two faces, and if the ion-site forces were the same for any given ion with respect to both sheets, this new configuration should find half the ions from each sheet transferred to the other. Such an exchange has now been found to occur by observing the transfer of radioactive potassium-42 from a mica sheet on to which it had been exchanged from aqueous solution[3] to another sheet initially inactive. When such an experiment was performed by simply pressing the two sheets of mica together on a flat surface, the amount of activity transferred was only 10 per cent of that initially present. This would suggest that the sheets were in contact over only 20 per cent of their area. This result is in line with the initial transfer values for stearic acid monolayers between mica surfaces pressed together, as found by Rideal and Tadayon[4]. When the area of ntimate contact was observed by multiple-beam interference techniques, however, the amount of transfer was found to be nearly half the total exchangeable potassium in that area.

Sheets of silvered mica were prepared and used for contact area measurement by the methods described by Bailey and Courtney-Pratt[5]. After cleaving the silvered sheets, and before the pieces were put into contact, the unsilvered side of one piece was rinsed with a 10^{-3} *N* potassium chloride solution containing potassium-42, rinsed with acetone, and dried. The two pieces of mica were then inserted in the clamps and brought into contact under the microscope. The area of uniform tint was measured with a micrometer eyepiece, the strips were then separated (total contact times were 2–8 min.) and the central portion of each, which included the contact area, was cut out and its activity measured under an end-window Geiger–Müller counter. (The area of contact was always a negligible fraction of the total area of the counting sample.) The results are collected in Table 1. Since the mica sheets were not especially selected for thickness, the sensitivity of the contact area measurement was not high nor necessarily reproducible. Especially in the case of the smaller contacts, where the activity transferred was also small, the observed values may be in considerable error. It is apparent, however, that the amount of potassium-42 transferred was very nearly half that initially present on the exchanged sheet. That initial activity, furthermore, was in satisfactory agreement with the activity calculated for complete surface potassium exchange with the solution used (1,300 counts/min./cm.^{2}).

Derjaguin *et al.*[6] have proposed a charge separation mechanism to account for their (rather higher) observed cleavage energies of mica. There seems to be no reason why surface potassium ions distributed in patches might not be invoked to provide their charge mosaic. As they suggest, the forces between such patches would still be large at appreciable separation of the sheets and would lead to gas dis-

Table 1. Observed Potassium-42 Activity on Contacted Mica Sheets

	Exchanged sheet, observed (c./min./cm.^{2})	Contact area (cm.^{2})	Contacted sheet (c./min.) obs.*	Transferred activity (c./min./cm.^{2})
1	1,044	0·052	21·1 (1·9)*	406
2	1,357	0·127	83·2 (3·7)	655
3	1,295	0·011	11·7 (1·6)	1,062
4	879	0·134	31·5 (2·1)	235
	1,144	Average values		590

* Counting standard deviations shown in parentheses. All count-rates corrected for background, counter resolving time, and corrected for decay to the same (zero) time.

charge. At the higher rates of cleavage which they used, moreover, such behaviour may be more likely than if the cleavage occurs as a nearly equilibrium process. (This point has been brought out by Miss Bailey[7].) The present experiments, of course, cannot distinguish between a uniform distribution of potassium ions and an array of small patches, and therefore I am not able to evaluate the importance of this contribution.

I am greatly indebted to Miss C. P. Rutkowski for experimental assistance and to Dr. David Tabor for interesting discussions.

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Feb. 9.

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Material Transfer in Monomolecular Layers of a Boundary Lubricant

Bailey and Courtney-Pratt[1] have studied the shearing of monomolecular layers of calcium stearate between flat mica sheets. They concluded that this shearing in the boundary lubricant film, which may afford almost perfect protection against wear, still contributes significantly to sliding friction. The processes which occur in the contact of such atomically flat surfaces protected by boundary films are therefore of some interest. It has been shown that mica surfaces brought into contact interchange the exchangeable potassium ions on their surfaces (preceding communication). This observation seems to support the postulate that the adhesive force between mica surfaces is ionic in nature[2]. Rideal and Tadayon[3] observed transfer of stearic acid from monolayers deposited on mica to other mica surfaces, but the major portion of their work seems to have been concerned with surface diffusion processes rather than true contact transfer.

In this communication the results of some preliminary measurements of area of true contact and transfer of stearic acid from monolayers, as well as migration of surface potassium ions through such monolayers are reported. The methods of Bailey and Courtney-Pratt[1] were used to measure contact areas and the potassium ion transfer was detected with potassium-42, as in the previous communication. Potassium ion migration was observed from an ion-exchanged mica surface[4] to a sheet of mica coated with a monolayer of commercially pure stearic acid (Armour 'Neo-Fat 18'). Stearic acid transfer was observed by measuring the activity transferred from a mica surface coated with a monolayer of stearic acid labelled with carbon-14 at the carboxyl group to an untreated surface. In both types of experiments, monolayer deposition was accomplished by the Blodgett technique[5], using a distilled water substrate and a surface pressure of about 30 dynes/cm. (oleic acid piston oil). The stearic acid was spread from hexane solution. The results of the transfer measurements are recorded in Table 1.

Table 1. Transfer of Potassium-42 and Stearic Acid-^{14}COOH Between Mica Surfaces

A. Potassium ion transfer in the presence of a stearic acid film

	Potassium-42 exchanged sheet, observed (c./min./cm.^{2})*	Contact area (cm.^{2})	Contacted sheet (c./min.) obs.*	Transferred activity (c./min./cm.^{2})
1	290 (10)	0·052	11·2 (2·8)	214
2	1,100 (15)	0·092	20·6 (1·8)	224
3	900 (10)	0·002	1·7 (1·6)	850

(Samples 2 and 3 from a different lot of potassium-42 than sample 1.)

B. Stearic acid-^{14}COOH transfer.

	Monolayer-coated sheet, observed (c./min./cm.^{2})*†	Contact area (cm.^{2})	Contacted sheet (c./min.) obs.*	Transferred activity (c./min./cm.^{2})
1	313 (3·0)	0·093	6·2 (0·5)	67
2	—	0·0051	1·5 (1·1)	294
3	—	0·016	1·1 (1·0)	68
4	—	0·018	2·0 (1·1)	111

* Counting standard deviations in parentheses. All counting-rates corrected for background, counter resolving-time and decay, where appropriate.
† Samples 1–3 were all coated from the same spread monolayer. Sample 4 was a separate monolayer spread from the same solution.

It is apparent from Table 1 that these results obtained are very crude and must be considered as preliminary. It is, however, clear that some transfer of both stearic acid and potassium ion does occur. Whether transfer of potassium ions occurs here through formation of a soap and migration of the entire soap molecule cannot be decided on the basis of the present results—radioactivity measurements of higher precision (which would require reagents of higher specific activity than were at hand in this work) would be needed to decide this point. The interesting differences in diffusion transfer of monolayers observed by Rideal and Tadayon make this point of some interest in connexion with the processes occurring in boundary lubricant layers. The ability of molecules to move from monolayers on one member of a sliding couple to the other member will be important in the protection of the surfaces, and the possibility of transferring metallic ions either through the monolayer or in conjunction with overturning lubricant molecules must be recognized.

I am indebted to Miss C. P. Rutkowski for assistance with these experiments.

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Feb. 9.

[1] Bailey, A. I., and Courtney-Pratt, J. S., *Proc. Roy. Soc.*, A, **227**, 500 (1955).
[2] Gaines, jun., G. L., and Tabor, D., *Nature*, **178**, 1304 (1956).
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A New Method of Integration Recording

The method now commonly used for recording continuously and in real time the integral of an instrument output signal requires the counting of pips in the final record. It is therefore essentially digital in nature. We have devised in our laboratory an analogue method (patents applied for) that eliminates counting and produces a new form of record, an 'integram', that appears to be particularly interesting and useful for gas chromatography.

The general scheme of the method is shown in Fig. 1. A conventional pen servo responsive to the signal drives the pen across the chart in the usual

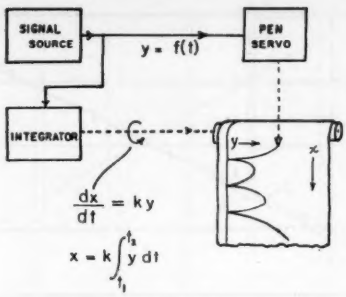

Fig. 1

way. The distinctiveness of the technique lies in the manner of driving the chart, namely, at a rate proportional to the recorded signal. By definition, the required chart drive mechanism is a form of integrator.

The familiar ball-and-disk integrator, with its input shaft driven by the pen transport mechanism and its output coupled to the chart drive, would appear to answer the practical requirements quite well and could be the basis of a relatively low-cost system. In the apparatus we actually employed to make the recordings shown, however, it was expedient to use a velocity servo type of integrator[1]. We inserted a conventional attenuator between the signal source (the gas chromatograph detector) and the pen servo, and a second attenuator (for signal reduction in ratios of 1 : 5 : 20) between the output of the first attenuator and the integrator. The velocity servo comprised a high-gain amplifier driving a motor and a direct-current tachometer. The tachometer output, fed back inversely to the servo-amplifier input, caused the servo output shaft, and thus the chart, to be driven at a rate proportional to the servo input signal.

The separate attenuator at the input of the velocity servo is necessary because the duration of gas chromatography peaks may vary over a considerable range: 20 to 1 or more. Thus, when peaks occur that are long lasting and also of large amplitude, the chart speed per unit of pen deflexion may be reduced to avoid excessive run-off of paper. As an auxiliary paper-saving feature, a switch may be mounted on the recorder whereby the pen drive at the upper limit of travel short-circuits the input to the servo-amplifier. The chart is thereby arrested during intervals when the pen is off the scale. Integration information is, of course, lost during such intervals, but in this respect the system does not differ from other recorder-coupled integrating devices.

For change-over at any time to conventional chromatographic recording, it is necessary only to operate a switch that substitutes a constant voltage at the input of the servo-amplifier in lieu of the gas chromatographic signal, so that the chart is driven at constant speed.

Fig. 2*b* shows a typical integram. The corresponding conventional chromatogram is shown in Fig. 2*a*. The records shown were run simultaneously on a sample of equal parts of *n*-pentane, *n*-hexane and *n*-heptane. (The discrepancy between corresponding peak heights in the two recordings is due to an inexact divider used at the input of the integram recorder.)

Of primary interest is the property that the base width of each peak in the integram is proportional to the area of the corresponding chromatogram peak. Thus, the integram shows at once that the components are approximately equal in quantity, a fact not easily discerned in the conventional recording. We note, too, that the integram contours terminate sharply in the base line at well-defined points and with steep slopes, whereas 'skirts' tapering gradually to zero slope appear in the corresponding chromatogram. This has been found to be true even when extensive tailing occurs. The integram therefore clearly defines the integration limits. As a note of interest, the property of sharp termination applies equally to a variety of functions (of signal vs. time) that might be encountered in instrumental measurements, for example, Gaussian distributions, exponential decay and displaced sinusoidal functions such as $y = 1 + \sin \omega t$.

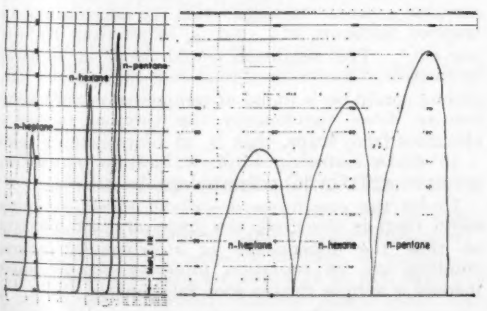

Fig. 2. (*a*) Chromatogram and (*b*) integram. Sample: 0·02 ml. *n*-pentane, *n*-hexane and *n*-heptane (1 : 1 : 1); chromatogram chart speed, 0·5 in./min.; integram chart speed, 8 in./min./100 per cent signal; column, 6 ft., silicone 550, 40–60 *C*-22 firebrick; temperature, 91° C.

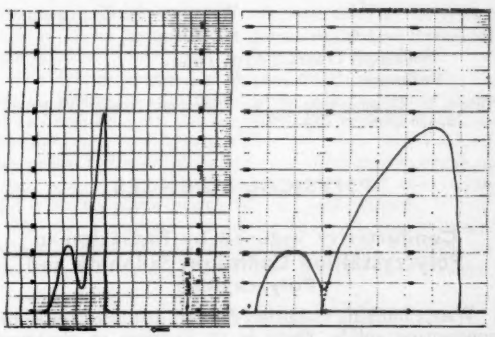

Fig. 3. Incompletely resolved peaks. Sample, 0·03 ml., methyl ethyl ketone and *cyclo*hexane (2 : 1). Conditions as in Fig. 2

Fig. 3 shows an example of the curves obtained on incompletely resolved components. Without prior knowledge of the peak shapes, it would be pure guesswork to extrapolate the overlapping curves in the chromatogram at the left in order to determine individual integration limits. In the corresponding integram, however, extrapolation is much more reliable. Given the degree of resolution shown, we can predict with some confidence (especially for the larger peak) where the extrapolated curves would meet the axis. Experience indicates that the shape of the integram for a given component remains quite characteristic and exhibits no surprising changes of direction as it approaches the axis. Thus a French curve laid against the integram contour can give a

useful extrapolation. A point of special interest is that, having extrapolated one of the adjoining, unresolved peaks, we resolve also the uncertainty for the other, because in the integram both extrapolations join the axis at a common point. This follows from the fact that total integram base-width for adjoining peaks is proportional to the sum of the separate integrals and independent of degree of resolution (on the reasonable assumption that detector response is linearly additive for superposed components).

Characteristically, the integram does not indicate elapsed time. Thus the integram of Fig. 2 does not tell how long the signal remained at zero between peaks, or the times at which the maxima occurred. A simple adaptation of the recorder, however, furnishing a supplementary time trace, permits this information to be embodied in the record. The integram may, for example, be confined to half the chart width (without serious loss of accuracy since the quantitative information of interest resides mainly in the width of the integram peaks, not their heights). A second pen is then provided which is driven laterally across the other half of the chart at a suitable constant speed. The supplemental trace thus obtained completely correlates the events of the integram with elapsed time, exhibiting plateaux in the lateral chart direction during the time intervals between peaks, and inflected steps between the plateaux marking the chromatogram peaks.

This work was announced at the Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy on March 6, 1958.

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PHYSICAL SCIENCES

Conductivity induced by Radiation in Polycrystalline Cadmium Sulphide and Polyethylene

When ionizing radiation falls on insulating or semiconducting solids, there is an increase in electrical conductivity resulting from the production of electron-hole pairs. If the source of ionizing radiation is removed, the conductivity decreases at a rate dependent upon the release of electrons from traps into the conduction band.

For any system with a continuous distribution of traps, it has been shown[1] that the curve of conductivity decay following excitation by radiation is approximately hyperbolic, and is given by the equation:

$$\frac{1}{n} = \frac{1}{n_0} + \frac{(m)}{(M_E)}\,\frac{bt}{kT} \qquad (1)$$

where n is the number of electrons per unit volume in the conduction band at any time t after removal of the exciting radiation and n_0 is the value of n at $t = 0$; b is the recombination coefficient of electrons with the original centres; m is the number of trapped electrons per unit volume and M_E is the number of traps per unit volume per unit energy-range. The departure from hyperbolic decay in cadmium sulphide has been used by Broser and Broser-Warminsky[2] to calculate the detailed distribution of traps in depth.

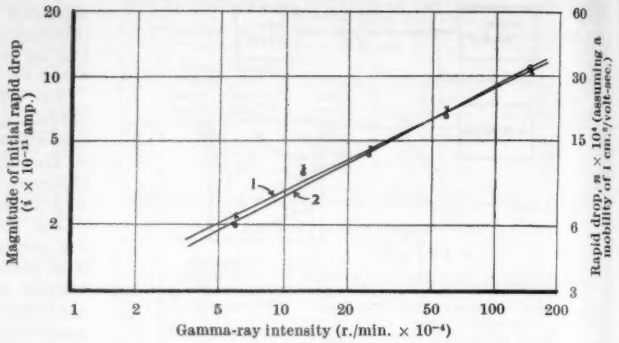

Fig. 1. Two crystals, (1) and (2), of polycrystalline cadmium sulphide at −55° C.

This theory leads one to believe that if thermal equilibrium between electrons in the conduction band and those in traps is not valid, as would occur if the rate of release from traps were smaller than the rate of recombination, a rapid drop in current would be observed until the rates became comparable. Thereafter equation 1 would be followed. The time constant for this rapid decay is of the order of $1/bm$. The time constant of the main decay following the rapid fall is of the order of $1/bn_0$; that is, larger than the rapid decay by the ratio m/n, approximately.

We have obtained support for this aspect of the theory from observations of an initial rapid decay in cadmium sulphide and in polyethylene under irradiation by gamma- and X-rays, respectively. Although these substances have conductivities which differ by orders of magnitude, the mechanism of induced conductivity is expected to be the same. Both substances normally show a similar dependence of induced conductivity on dose-rate, namely:

$$\sigma \propto R^{0.85} \qquad (2)$$

where R is the dose-rate.

There are two conditions for which an excess of conduction electrons would be present to cause this initial rapid drop. One is at extremely high intensities of radiation, where the concentration of free carriers, n, would be larger than the concentration of trapped electrons, m; that is, larger than 10^{14}–10^{17} per cm.^{3}. This condition would occur at radiation intensities of the order of megarads per minute. The second condition is found at temperatures sufficiently low to delay significantly the thermal release of electrons from traps, that is, at temperatures below −10° C. in cadmium sulphide, and at room temperature (20° C.) in polyethylene.

Under the conditions described, where an initial rapid drop is observed, the traps are not effective, so that the dependence of steady-state induced conductivity on radiation intensity should follow instead a simple square root relationship:

$$\frac{dn}{dt} = 0 = Q - bn^2$$

or,

$$n \propto Q^{1/2} \qquad (3)$$

where Q is the ionization-rate per cm.^{3}.

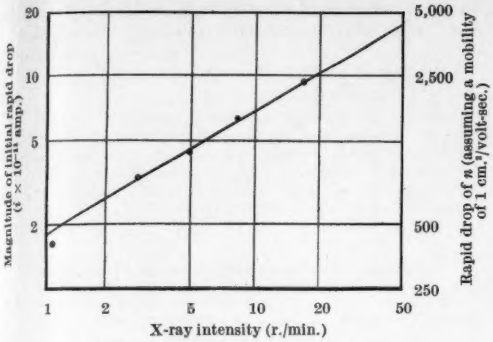

Fig. 2. Polyethylene at + 20° C.

We find experimentally that this is so to a reasonable degree of accuracy.

Fig. 1 shows curves relating to cadmium sulphide in which the logarithm of the magnitude of the initial drop has been plotted against the logarithm of the radiation intensity, yielding an exponent of 0·48 in equation 3. Fig. 2 shows similar curves for polyethylene, where the exponent is 0·56.

For substances with an exponential distribution of traps, Rose[3] gives the variation of induced conductivity with dose-rate and temperature as:

$$\sigma \propto R^{T_1/(T+T_1)} \qquad (4)$$

where T_1 is a constant of the substance which has the dimension of temperature, and which has been suggested as being the 'trap melting point'. Both these substances have values of T_1 about 1,500° K., and it has been shown[2] that for substances having such high values of T_1 an initial drop is more likely than for substances having a lower value of T_1, approaching room temperature.

Support is therefore afforded for the conception of photo-conductive trapping and decay as applied to ionizing radiation falling on insulating or quasi-insulating substances.

We are indebted to Dr. S. T. Henderson, Thorn Electrical Industries, Ltd., for supplying the polycrystalline cadmium sulphide layer cells.

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Refractive Index of Uranium Oxide produced by Anodic Oxidation

During a study of the anodic oxidation of uranium it was found that brilliant interference colours could be obtained using an aqueous solution of ammonia as electrolyte. The film was found to be non-absorbing up to the maximum voltage which could be applied without pitting of the metal, that is, 270 V. Flint *et al.*[1] have studied the anodic oxidation of uranium in various electrolytes and consider that ammoniated ethylene glycol only can be used for producing interference films without pitting.

It was considered that, providing the refractive index could be determined, the kinetics of film growth could be studied with advantage by an optical reflectivity method. Separation of the anodic oxide from the metal was not possible, and the bulk oxide could not be used for this determination since the chemical and physical nature of oxide films produced by anodic oxidation usually differs from oxides prepared thermally or chemically.

An investigation of the solubility of the anodic oxide revealed that it dissolved readily in dilute sulphuric acid, which, however, did not attack the underlying metal. It was thus possible to remove the anodic oxide film completely from part of the specimen, forming a sharp oxide step which could be measured, after silvering, by multiple beam interferometry using reflected light[2]. It is of interest to observe that this method is not applicable to the refractory anodic oxides produced on tantalum, zirconium, niobium and titanium.

The refractive index calculated using this method gave $\mu = 1{\cdot}93$.

The above technique has, however, been extended to provide a method which is applicable even if the metal is slightly soluble in the acid since, by suitably controlling the dissolution of the oxide in the acid, a wedge of oxide could be produced on the metal surface. An examination of this oxide wedge revealed dark fringes, in the direction of the wedge length, which corresponded to successive orders of interference minima in the oxide. The specimen was suitably mounted in conjunction with a silvered reference flat so that a further fringe system was produced at right angles to the fringe system in the oxide wedge. A composite fringe system was thus obtained in which the multiple-beam fringes became laterally displaced in crossing the wedge. By means of an eyepiece micrometer the intersection of these fringes with the order fringes could be located.

The fringe system is shown diagrammatically in Fig. 1, where *aa* represents order fringes in the oxide wedge and *bb* multiple-beam fringes formed between the flat and specimen. The physical thickness of the oxide between successive interference minima is $\lambda/2\mu$, where μ is the refractive index of the oxide and λ is the wave-length of the light source.

The displacement d of fringe *bb* in passing between adjacent minima *aa* corresponds to an increase in optical path of λ/μ, and the distance D between

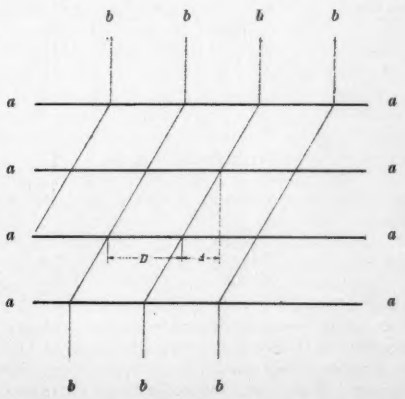

Fig. 1. Composite fringe system

successive *bb* fringes corresponds to change in optical path of λ. Hence,

$$\mu = \frac{D}{d}$$

An average value of several determinations embracing four orders of interference gave $\mu = 1{\cdot}95$ for uranium oxide produced by anodic oxidation.

This value is in good agreement with the value for the refractive index determined by the previous method. The accuracy of the determination was limited by irregularities in the metal surface and by the broad fringes obtained, and it was not possible to determine whether μ varied within the thickness of the oxide wedge.

A determination of the refractive index of thermally prepared uranium oxide by Brewster angle measurements on the polished face of a sintered block gave a much higher value, namely, $\mu = 2{\cdot}26$ for uranium oxide produced thermally.

Using the value $\mu = 1{\cdot}95$, the growth-rate of the oxide during anodizing in ammonia solution was found to be 28 A./V.

Acknowledgments are made to the U.K. Atomic Energy Authority (Harwell) for kindly sponsoring this research.

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Frequency of Meteorite Falls throughout the Ages

As recently as in 1956 the late Prof. F. A. Paneth, an authority on meteorite investigations, published a paper under the above heading[1], in which he wrote: "iron and stone meteorites did not fall before the late Quaternary".

Thanks to studies carried out here in Sweden on the 'cosmic spherules' discovered by J. Murray in 1876 [2], which are present in the long cores of sediment raised from great ocean depths by the Swedish Deep Sea Expedition in 1947–48 by means of the Kullenberg piston-core sampler[3], we are now able to refute this hypothesis. We have been able to extract from the sediments cosmic spherules identical with those described by Murray but in much greater numbers, from tens to a couple of thousands per kilogram of red clay[4,5]. Also in the deepest sections of cores from the Pacific Ocean, dating back to the Tertiary Age, such spherules were found. It is to be hoped that by more extensive investigations of this kind a new chronology for deep-sea deposits may be evolved, going back much further in time than is possible by means of radioactive measurements.

This communication (detailed papers are being prepared) is chiefly meant to be a plea for studying the cosmic spherules present in long cores of sediment which will be obtained by future deep-sea expeditions. In case the plans for drilling a hole through the deep-ocean sediments down to the underlying bedrock, repeatedly referred to in *Nature*[6], are realized, a study of the cosmic spherules present in the different layers penetrated will afford a unique record of the variations in meteor frequency since the oceans came into existence. This result alone will make it eminently worth while to realize the grandiose project, the total costs of which will amount only to a fraction of the costs of sending a manned rocket to the Moon.

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Chemical Composition of Tektites

In a recent communication, Brian Mason[1] asks that I supply a list of chemical compositions of sedimentary rocks which parallel those of the tektites. I offer the following references for his samples of tektites labelled A_1–G_1. The pages in the following list refer to Pettijohn's book on sedimentary rocks[2]: A_1, 298; B_1, 364; C_1, 319; D_1, 319; E_1, F_1, and G_1, 306. Except for water content, fair agreements between analyses can be secured by selecting analyses from these tables. The low water content of tektites is a real puzzle. There are some small differences in analyses between those listed by Pettijohn and the tektites. It is very probable that some granites of the composition listed by Mason are fused sediments. What would be more interesting than an argument about average sedimentary rocks would be a comparison of the composition of particular groups of tektites and sedimentary or igneous rocks in the general area in which the tektites are found. If cometary collisions melted the local rock and scattered the fragments over great distances[3], it should be possible to find the original material at an appropriate place. But this requires study by an expert in these matters and probably additional observational data, and these cannot be supplied by me.

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BIOCHEMISTRY

Are Nucleoside Triphosphates Precursors of Mammalian Ribonucleic Acid *in vivo*?

When albino rats are kept for 6–7 weeks on a protein-free diet they lose about half their body-weight[1]. At the same time, almost 50 per cent of the liver proteins and ribonucleic acid disappear: this can only be explained by a decrease in their biosynthesis.

We have studied the liver supernatant, because in this particular fraction loss of nucleoside di- and tri-phosphates during differential centrifugation can be prevented by the addition of ethylenediamine tetraacetate to the separation medium, whereas nucleoside polyphosphates are hydrolysed to monophosphates in the mitochondria and microsomes.

Protein deprivation results in the disappearance of 56 per cent of the proteins and 36 per cent of the ribonucleic acid in the supernatant, while there is an accumulation of adenosine triphosphate (4·7 times the control), guanosine and uridine triphosphates.

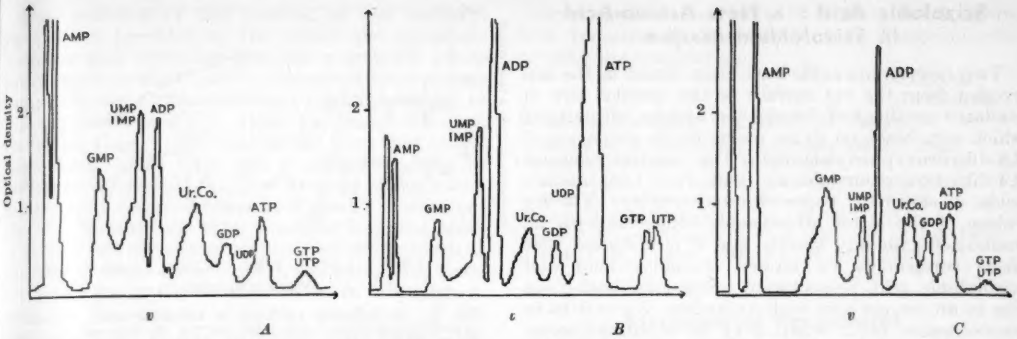

Fig. 1. Free nucleotides of rat liver supernatant, separated on a column of 'Dowex' 1×8, 200–400 mesh, 0·8 cm. × 30 cm. Gradient elution through formic acid and formic acid – ammonium formate: *A*, controls; *B*, deprived animals; *C*, protein deprivation followed by normal feeding

Note the increased ATP, GTP and UTP (adenosine, guanosine and uridine triphosphates) peaks after protein deprivation, and the return to normal when rats are fed normally for three days after six weeks protein deprivation.
Optical density measured at 2600 A. in a 1-cm. cuvette; *v*, eluant volume; *Ur.Co*, uridine coenzymes

No cytosine triphosphate could be detected in our experimental conditions either in controls or in deprived animals. This increase of nucleoside triphosphates, parallel with the reduction in the synthesis of ribonucleic acid, suggests that these nucleotides are the precursors of ribonucleic acid. The decrease of ribonucleic acid in the supernatant cannot be due to absence from the diet of the amino-acids glycine, glutamic acid and aspartic acid, precursors of the purine and pyrimidine rings, since these amino-acids are not indispensable.

The results show, for the first time in the case of mammals *in vivo*, that the synthesis of ribonucleic acid is dependent on the synthesis of protein: after protein deprivation, we find a drop in proteins and in ribonucleic acid but an accumulation of nucleoside triphosphates in the supernatant; when rats, deprived of proteins for six weeks, are afterwards fed normally for three days, a rapid increase in proteins occurs, which is paralleled by that of ribonucleic acid, while the nucleoside triphosphates revert to normal levels.

We also incubated whole liver slices of controls and deprived animals for 20 min. at 37° C. with or without a complete mixture of amino-acids. These amino-acids are without effect on the incorporation of phosphorus-32 into ribonucleic acid in the controls. In the case of deprived animals, in which the pool of free amino-acids is certainly small, incorporation of phosphorus-32 is considerably enhanced by the addition of the amino-acid mixture. This suggests that the syntheses of protein and of ribonucleic acid are concurrent processes (which we are now trying to prove by the use of amino-acids labelled with carbon-14). No net increase in the quantity of ribonucleic acid can be detected in such a brief time of incubation, but the greater incorporation of phosphorus-32 seems to afford sufficient evidence. The fact that the ribonucleic acid fraction remaining after protein deprivation shows a greater incorporation (*in vivo* as well as *in vitro*) is discussed elsewhere[2].

Table 1. Incorporation of Phosphorus-32 into Rat Liver Ribonucleic Acid *in vitro*

Whole liver slices were incubated for 20 min. at 37° C. with or without a complete mixture of amino-acids. Values are in c.p.m. per 100 μgm. of ribonucleic acid phosphorus

Experiment No.		Without amino-acids	With amino-acids
1	Controls	490	570
	Deprived animals	2,610	4,550
2	Controls	400	520
	Deprived animals	2,060	3,560

In other words, while it appears to be well established that ribonucleic acid is indispensable in protein synthesis, it also seems that little or no ribonucleic acid is synthesized when protein synthesis is stopped or at least slowed down by deprivation of nitrogen. This agrees with facts observed in micro-organisms[3]. In any event, it seems highly improbable in the light of present knowledge that the cell should synthesize proteins on one hand and ribonucleic acid on the other, both of which would afterwards combine to form specific nucleoproteins. The synthesis not of proteins and ribonucleic acid separately but of nucleoproteins from amino-acids and nucleotides would explain the known facts, namely, the role of ribonucleic acid in protein synthesis and vice versa. This synthesis of ribonucleoproteins may occur by condensation of nucleotide – amino-acids complexes. Hitherto, only adenosine monophosphate–acyl complexes have been described. Our hypothesis postulates the existence of guanosine, uridine and cytosine monophosphate complexes. The fact that these complexes have not so far been discovered does not constitute proof that they do not exist.

This hypothesis might be extended to other classes of heteroproteins. Hendler[4] recently reported that lipids play a part in the synthesis of proteins. It is possible that synthesis of certain lipoproteins occurs through condensation of amino-acid – lipid complexes, and that of some glycoproteins by condensation of amino-acid – saccharide complexes.

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Stizolobic Acid : a New Amino-Acid in *Stizolobium hassjoo*

Two new amino-acids have been found in the sap exuded from the cut surface of the epicotyl tips of etiolated seedlings of *Stizolobium hassjoo*, all parts of which turn black on dying owing to the oxidation of 3,4-dihydroxyphenylalanine. The exudate contains 3,4-dihydroxyphenylalanine and two new amino-acids, as shown by paper chromatography. The R_F values of the latter amino-acids coincided with no amino-acids already known, and it is proposed that these compounds be named stizolobic acid and stizolobinic acid, respectively. Stizolobic acid gives rise to an orange spot with ninhydrin ($R_F = 0{\cdot}16$ in phenol/water (8 : 2 w/w), 0·11 in *n*-butanol/acetic acid/water (4 : 1 : 2 v/v)), while stizolobinic acid gives a brown spot ($R_F = 0{\cdot}24$ in phenol/water, 0·14 in *n*-butanol/acetic acid/water).

Stizolobic acid was isolated from the combined exudates by ion-exchange column chromatography (*IR*–4*B*—0·05 *N* hydrochloric acid displacement) and obtained as colourless needles, which melted at 231–233° C. after recrystallization. Since the content of stizolobic acid in the plant is very small, the yield from about 10 kgm. seeds was only 10 mgm.

The empirical formula of stizolobic acid was found to be $C_9H_9O_6N$ (found : C, 47·91 ; H, 3·96 ; N, 6·45 per cent ; calc. : C, 47·62 ; H, 4·00 ; N, 6·17 per cent). All nitrogen belongs to amino group as measured by van Slyke's method (found amino-nitrogen, 6·05 per cent). It was shown to contain an α-amino group by its complexing with copper[1], and to be an acidic amino-acid by paper electrophoresis. The results of alkaline titration of the carboxyl group in 90 per cent ethanol showed that it was possibly a dibasic acid. Addition of bromine was not successful, and attempted reaction with carbonyl reagents was also unsuccessful. However, stizolobic acid was attacked by ozonolysis and absorbed about 2·5 mol. hydrogen on catalytic hydrogenation in the presence of a palladium–carbon catalyst, yielding two products, both of which were acidic amino-acids and gave purple spots with ninhydrin. One of them, which was a major product when hydrogenation was interrupted soon after 2 mol. per cent had been absorbed, reacted with 2,4-dinitrophenylhydrazine to form yellow crystals. These properties made it probable that stizolobic acid itself might have a special type of carbonyl group or groups and two —C=C— bonds, and led us to suppose the presence of a γ-pyrone nucleus.

Many γ-pyrone compounds absorb 2–3 mol. hydrogen on catalytic hydrogenation, producing tetrahydro-γ-pyrone compounds and tetrahydro-γ-pyranol compounds, the former reacting with carbonyl reagents[2]. If a γ-pyrone is assumed to be present as an integral part of stizolobic acid, it would readily explain the fact that the carbonyl group does not show ordinary addition reactions, and suggest that the two products are probably a tetrahydro-γ-pyrone compound and tetrahydro-γ-pyranol compound.

The analysis of infra-red spectra of stizolobic acid and its deuterated product gave further support for the γ-pyrone structure of stizolobic acid (Fig. 1). From the data, considering chemical properties, the presence of the following groups could be deduced : NH_3^+, COO^-, non-ionized COOH group (another carboxyl group), two or more H atoms in $=\overset{H}{\underset{|}{C}}-$

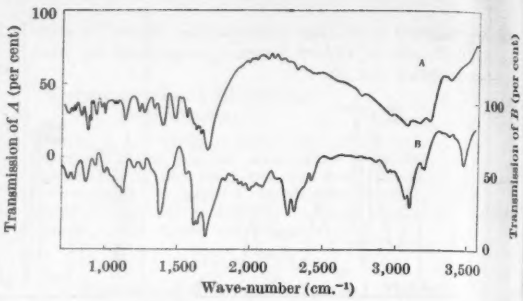


Fig. 1. *A*, Infra-red spectrum of stizolobic acid. Solvent : hexachlorobutadiene (1,300–1,500 cm.$^{-1}$); *B*, infra-red spectrum of its deuterated product. Potassium bromide disk (750–1,800 cm.$^{-1}$). Solvent : hexachlorobutadiene (1,800–3,500 cm.$^{-1}$)

groups and one or more —C=C— groups probably conjugated with a —C=O group. The spectra are also not inconsistent with the presence of a =C—O—C= group.

Ozonolysis of stizolobic acid gave aspartic acid, oxalic acid and formic acid. Aspartic acid was also produced on oxidation with potassium permanganate. From these results it seemed likely that stizolobic acid might contain $=CCH_2CH(NH_2)COOH$, =CCOOH and =CH groups. Considering the possible presence of the γ-pyrone nucleus, the structure of stizolobic acid might be assumed to be β-(carboxy-γ-pyronyl)-alanine.

Degradation with boiling 3*N* sodium hydroxide for 3 hr. gave glutamic acid as a major ninhydrin-reacting product and malonic acid, oxalic acid and another unidentified acid as non-volatile organic acids, and formic acid. No acetone was detected. From the examples of alkaline degradation of chelidonic acid[3], comanic acid[4], 2,6-dimethyl-γ-pyrone-3,5-dicarboxylic acid[5] and other γ-pyrone compounds[3,6], formation of glutamic acid by the alkaline degradation of stizolobic acid indicates that the side-chain $—CH_2CH(NH_2)COOH$ might be not on the C_2- or C_6-position, but on the C_3- or C_5-position. Formation of formic acid suggests that there might be no substituent on the C_2- and/or C_6-position, and since malonic acid is produced, the position of the carboxyl side-chain could not be deduced to be attached to other than the C_3- or C_5-position.

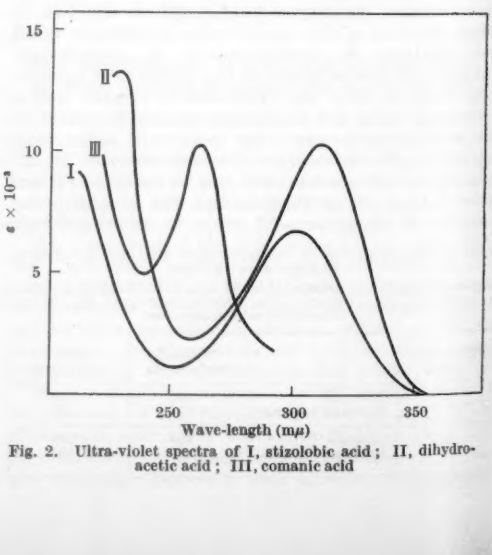
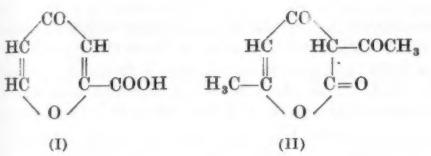
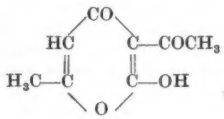


Fig. 2. Ultra-violet spectra of I, stizolobic acid ; II, dihydroacetic acid ; III, comanic acid

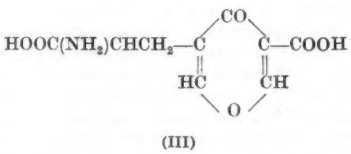
Some evidence of the position of the carboxyl side-chain is provided by the ultra-violet spectrum. Assuming that stizolobic acid has a carboxyl group as side-chain on the C_2- or C_6-position of the γ-pyrone nucleus, its ultra-violet spectrum might be similar to that of comanic acid (I). However, the spectrum of the former ($\lambda_{max.}$ = 300 mμ) differs from that of the latter ($\lambda_{max.}$ = 260 mμ), but is similar to that of dehydroacetic acid (II, $\lambda_{max.}$ = 310 mμ), which exists as a virtually completely enolized species in solution[7] (Fig. 2). As this form (II*a*) is similar from the point of view of ultra-violet absorption to the postulated structure of stizolobic acid (III), excepting that there is a —OH group on the C_2-position in (II*a*), which would be expected to shift the maximum of the spectrum by 10–20 mμ to longer wave-length, the postulated structure of stizolobic acid is not inconsistent with ultra-violet absorption data.



(I) (II)



(II*a*)



(III)

The results of electrophoresis indicated that stizolobic acid is a considerably stronger acid than other monoamino-dicarboxylic acids such as aspartic acid. This finding confirms the assumption that the side-chain of a carboxyl group might be on either the C_3- or C_5-position in the γ-pyrone nucleus, both of which would be expected to enhance the acidity, while a carboxyl group on the C_2- or C_6-position would be expected to show a weak acidity, because of a proton-attractive —O— group.

From all the evidence described above, it appears that stizolobic acid has the structure β-(3-carboxy-γ-pyron-5-yl)-alanine. In recent years a number of new, unusual amino-acids have been isolated from plant materials; but an amino-acid with a γ-pyrone nucleus such as stizolobic acid has not been found hitherto. It has been shown to be present in the various organs of *Stizolobium deeringianum*, *S. hassjoo*, *S. pruriens*, *S. utilis* and *Mucuna irukanda*, but it could not be detected in seeds of *Arachis hypogaea*, *Azukia angularis*, *Canavania gladiata* var. *alba*, *Glycine max*, *Phaseolus vulgaris*, *Pisum sativum*, *Vicia faba*, *Vigna sinensis* or *Wistaria floribunda*, or in the hydrolysate of the protein prepared from seeds of *Stizolobium hassjoo*.

A fuller account of the investigation will be published elsewhere.

Our thanks are due to Dr. E. C. Bate-Smith, of the Low Temperature Research Station, Cambridge, for revising the manuscript.

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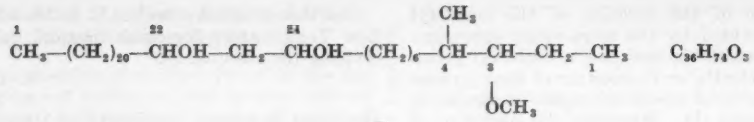
Structure of Phthiocerol

Phthiocerol, a characteristic constituent of the waxes of human and bovine strains of tubercle bacilli[1–3], was found by Stodola and Anderson[1] in 1936 to be a methoxy-glycol with the formula $C_{34}H_{67}(OH)_2OCH_3$ or $C_{35}H_{69}(OH)_2OCH_3$. About ten years ago it was shown that phthiocerol has a long-chain structure with a methyl branch in position 4[4–6]. More recently the presence of a β-glycol grouping was demonstrated[7,8], and several structural formulæ have been suggested on the basis of degradation experiments (for a review see ref. 9). Definite evidence that the methoxyl group is attached to carbon atom 3 adjacent to the methyl group was first obtained by a mass spectrometric study of phthiocerol[10,11], and this was afterwards confirmed by chemical studies[12–14]. The mass-spectrometric results also indicated the presence of a hydroxyl group in position 22 from the straight-chain end of the molecule. The mass spectrum of a purified sample of phthiocerane, the hydrocarbon obtained by reduction of phthiocerol[15], showed this compound to consist mainly of 4-methyltetratriacontane[11]. Structure (I) for phthiocerol was suggested on the basis of the mass spectrometric study[11].

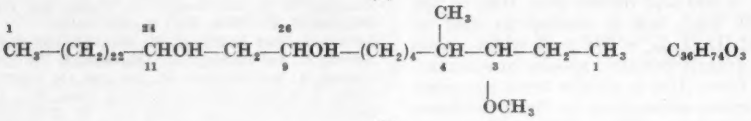
However, oxidative degradation of phthiocerol was found to give two acids, considered to be *n*-tetracosanoic acid[7,16] and a C_{11}-methoxy-acid respectively[16,17]. These results, together with the previously available evidence, led Drayson *et al.*[14] to put forward formula (II) for phthiocerol. Previously one of us (H. D-G.)[13] had suggested that phthiocerol was a mixture of (I) and (II).

Formula (II) takes no account of the fact that the 'tetracosanoic acid' obtained by chromic acid oxidation of phthiocerol following the procedure of Polgar *et al.* has been shown[11] to be a mixture of the normal chain carboxylic acids with 24, 23, 22 and 21 carbon atoms. The molar relations between these acids were 51 : 9 : 38 : 2. As it seems unlikely that the C_{22} and C_{21} acids have been formed by secondary processes from the C_{24} acid initially formed, the results appear explainable only on the assumption that phthiocerol from natural sources is a mixture of two glycols. One of these glycols must have the first hydroxyl group in position 22 from the straight-chain end and the other the same group in position 24.

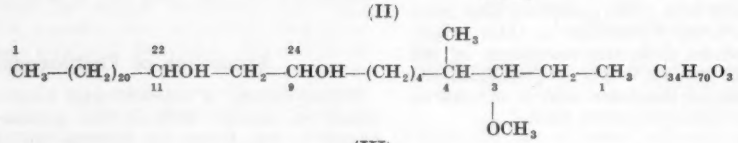
In order to clear up this matter, the products of the oxidative degradation of phthiocerol have been examined in some detail. The acidic products formed on oxidation using the procedure described by Drayson *et al.*[14] were converted into methyl esters by means of diazomethane and analysed by gas chromatography and mass spectrometry. The methyl ester of the 'tetracosanoic acid' fraction from a specimen of phthiocerol obtained from Dr. Polgar was found



(I)

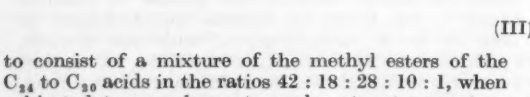


(II)

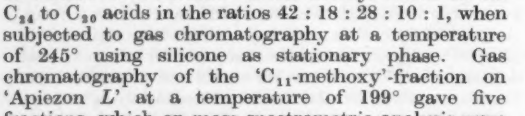


(III)

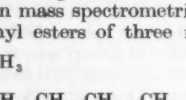
to consist of a mixture of the methyl esters of the C_{24} to C_{30} acids in the ratios 42 : 18 : 28 : 10 : 1, when subjected to gas chromatography at a temperature of 245° using silicone as stationary phase. Gas chromatography of the 'C_{11}-methoxy'-fraction on 'Apiezon *L*' at a temperature of 199° gave five fractions, which on mass spectrometric analysis were found to be methyl esters of three methoxy-acids:



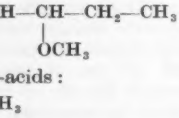
and two hydroxy-acids:



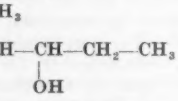
The mass spectra provide highly specific information in this case. The methoxy-esters give an intense peak at $m/e = 73$, which is also found for phthiocerol[11]. This peak is due to the ionized fragment:



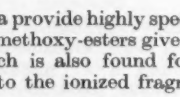
formed by cleavage of the chain between the carbon atoms carrying the methyl and the methoxyl group respectively. The hydroxy-esters just referred to, as well as the triol[7] obtained by demethylation of phthiocerol, give the analogous ion:



of $m/e = 59$ (ref. 19), whereas oxo-compounds of the general structure:



give a corresponding large peak at $m/e = 57$ due to the ion:



(ref. 19).

Quantitatively, the largest components of the 'C_{11}-methoxy'-fraction were the methyl ester of the C_{11}-methoxy-acid (about two-thirds of the total) and the methyl ester of the C_{10}-methoxy-acid, confirming the conclusions of Drayson *et al.*[14] that phthiocerol has a hydroxyl group in position 9 from the branched chain end. The ratio between the C_{11} and the C_{10}-methoxy-acids was about the same (3 : 1) as between the C_{24} : C_{23} and C_{22} : C_{21} pairs of acids respectively derived from the other end of the molecule. This evidence is in agreement with the view that phthiocerol is a mixture of two glycols. The compound might be either a mixture of two homologous β-glycols or a mixture of a β- and a δ-glycol[9,12].

In order to distinguish between these two possibilities, we have examined a specimen of phthiocerane[13] which we had prepared without recourse to purification by repeated crystallization from solvents. Gas chromatography on silicone at a temperature of 265° afforded a clean separation of this material into two fractions, the retention times being 13·8 and 22·2 min. respectively. A specimen of synthetic 4-methyltetratriacontane was found to have a retention time of 22·3 min. under the same conditions, and mass spectrometric examination of the isolated fractions from phthiocerane showed them to consist of 4-methyldotriacontane ($C_{33}H_{68}$) and 4-methyltetratriacontane ($C_{35}H_{72}$) respectively.

The results now reported show that phthiocerol is a mixture of two homologous β-glycols (II) and (III) with 36 and 34 carbon atoms respectively.

The quantitative relation between the C_{35} and the C_{33} components of phthiocerane (from B.C.G.) were approximately the same (3 : 2) as the ratio between the C_{24} and the C_{22} acids obtained by oxidation of a specimen of phthiocerol derived from virulent strains. As the specimens of phthiocerol had all been purified by crystallization from solvents, it seems likely that the homologues (II) and (III) are present in about equal proportions in the bacterial lipids.

The possibility that phthiocerane was a mixture of 4-methyldotriacontane and 4-methyltetratriacontane was suggested previously[5], but considered unlikely at that time because of the reported failure to separate phthiocerane into components by molecular distillation[13].

We are indebted to Prof. R. J. Anderson, Yale University, for specimens of phthiocerol and phthiocerane, and to Dr. N. Polgar, Oxford, for specimens of phthiocerol and of C_{11}-methoxy-acids.

We also thank the Fondation Waksman pour le Développement des Recherches microbiologiques en France and the Swedish Medical Research Council for several grants, and Drs. J. Tréfouël and J. Bretey

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Detailed accounts of this work will be published elsewhere.

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Changes produced in Serum Lipoproteins of Dogs by Cellulose containing Methyl Groups

It has been observed by several authors that macromolecular polysaccharides, especially those containing sulphate groups, cause significant alterations in the lipoprotein patterns of sera[1,2]. In the course of previous studies on the effect of methylcellulose on blood-proteins[3] certain changes in serum lipids were also noted. So it seemed to be of interest to examine what influence methylcellulose of high molecular weight (82,000) exerts *in vitro* as well as *in vivo* on the lipoproteins of sera of experimental animals.

Paper electrophoretic patterns of the lipoproteins in dog and rat sera were obtained after adding solutions of methylcellulose (in concentrations varying progressively from 1·5 to 0·1 per cent). Fig. 1 shows that the presence of methylcellulose considerably alters the chylomicrons but no change can be seen in the α- and β-lipoprotein fractions. The extent of the chylomicron zone is about the half that on the control strip and it is characterized by a sharp peak towards the line of application. The intensity of this peak tends to increase with the concentration of methylcellulose in the serum. Just the same change appeared in the lipoprotein pattern of sera of dogs 30–60 min. after they had received an intravenous

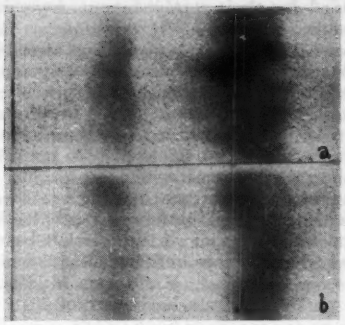

Fig. 1. (*a*) Lipoprotein electrophoretogram of normal dog serum; (*b*) the same serum after the addition of methylcellulose solution

injection of a 1 per cent solution of methylcellulose, but disappeared again in a short time. If a solution of methylcellulose was layered over lipæmic sera in capillary tubes, a loose aggregate was formed which later moved slowly upward, while the opalescence of the serum below the interface cleared up. These results suggest that methylcellulose is capable of exerting considerable influence on the large lipid particles of sera.

The lipoprotein pattern of dogs treated with 20 ml. of a 1 per cent solution of methylcellulose administered intravenously twice weekly for 3–5 months is presented in Fig. 2. The remarkable increase of a component between the alpha and beta peaks—faintly visible in some of the normal cases—can be observed on the electrophoretogram of dogs treated with methylcellulose. Furthermore, a significant rise in the cholesterol-level was also found after long-term treatment, its mean value being 340 mgm. per cent in treated and 222 mgm. per cent in untreated animals, respectively. Thus long-term administration of methylcellulose alters not only the electrophoretic pattern of lipoproteins but the cholesterol content of blood as well.

Results obtained by paper-electrophoresis with rats injected intraperitoneally with methylcellulose, as well as those described above, do not show any similarity to the heparin-like effect of cellulose sulphate described by Constantinides[1]. It seems therefore that the substituent groups are an important factor in the mode of action of macromolecular polysaccharides on the lipoproteins. Not only the character of the changes caused but also the

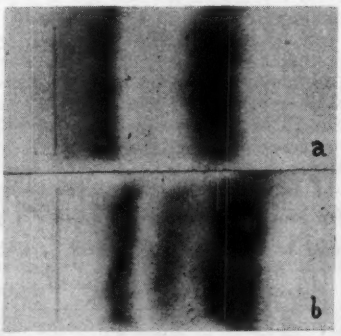

Fig. 2. Lipoprotein electrophoretogram of dog serum, (*a*) before, and (*b*) after, methylcellulose treatment

time needed for their establishment depends on the substituents.

Histological examination of six dogs after long-term treatment showed infiltrations mostly containing *mononuclear cells in the wall of the small arteries*, perivasculitis, a considerable intima proliferation and formation of granuloma in the interstitium of the lung tissue. This histological picture resembles that of thromboembolic arteriitis.

Further experiments are in progress in order to elucidate the mode of action of methylcellulose on the lipoproteins, as well as the relation between the lipoprotein disturbances and the histological picture.

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Gas-Chromatographic Observation of the Reduction of Carbon Dioxide to Methane during Anaerobic Digestion

Gas chromatography has been applied to the analysis of gases formed during methane fermentations[1]. It appeared to us that this technique could be used successfully for observing the mechanism of methane formation. Knowledge of the biochemistry of methane-producing bacteria is still superficial in many respects. Early observations of Söhngen[2] showed the possibility of the fermentation of a mixture of carbon dioxide and hydrogen by enrichment cultures of some anaerobic bacteria. These micro-organisms could couple the oxidation of hydrogen with the reduction of carbon dioxide to methane. More recently, Barker[3] had discussed the mechanisms by which carbon dioxide could be the precursor of methane.

In this laboratory a method of analysis of fermentation gases was applied using gas chromatography to separate various components of the gas mixture by argon elution from an absorption column packed with activated carbon. The detection of these components was achieved by a beta-radiation ionization chamber (ref. 4 and personal communication from A. T. James). A method based on this principle allowed the determination during a single analytical procedure of hydrogen, nitrogen, methane and carbon dioxide.

The gas-chromatography apparatus consisted of the sample-injection system, manometer, chromatographic column in an electrically heated jacket, beta-radiation detector, soap-film flowmeter and carrier-argon supply cylinder. The source of β-rays for the ionization chamber detector was 10 mc. of strontium-90 in silver foil in the shape of an open cylinder, which was mechanically and electrically joined to the body of the chamber. The chamber itself was constructed of brass and a 'Champion' *C–5* sparking plug, modified by the addition of a brass cap, was used as the central collecting electrode, with the radioactive cylinder surrounding it. The gas inside the cell of the detector was bombarded with β-particles and was ionized. When the walls of the chamber (and the radioactive electrode) were connected to a source of 300 V. from a voltage stabilizer, the ionization current collected by the central electrode was amplified and recorded by a Honeywell-

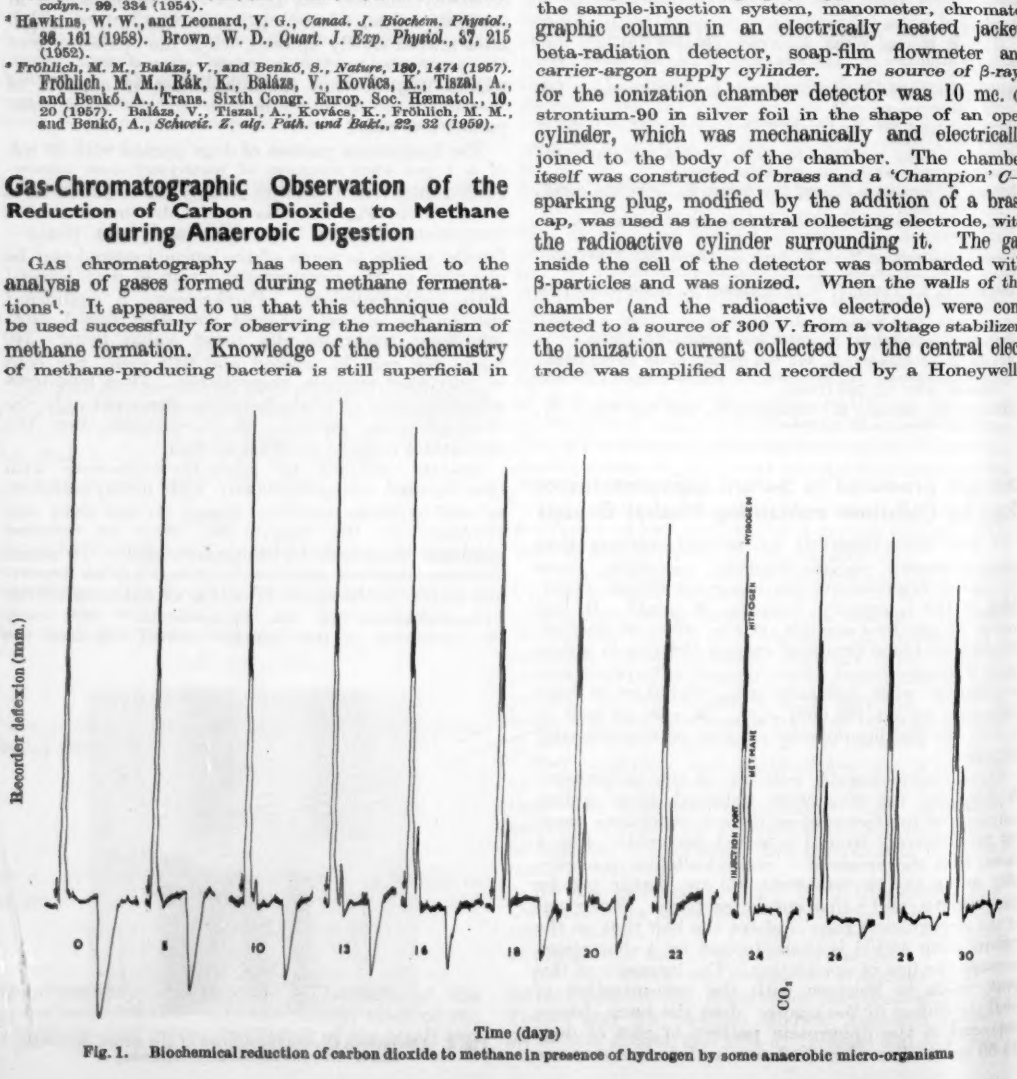

Fig. 1. Biochemical reduction of carbon dioxide to methane in presence of hydrogen by some anaerobic micro-organisms

Brown potentiometric recorder. The amplifier was adjusted so that the recorder indicated the chosen base-line for the constant flow of pure argon, and gave a deflexion for argon carrying other gases. The gaseous constituents separated by the chromatographic column were detected and recorded as more or less separate peaks on the time-deflexion graphs of the recorder. Relationships between peak height and volume of gas sample for hydrogen, nitrogen, methane and carbon dioxide were established and used as calibration curves for the determination of the gases resulting from the anaerobic processes. Higher sensitivity of the ionization detector for hydrogen and nitrogen than for carbon compounds was observed in this investigation. All the determinations were performed under standardized conditions as indicated in the next paragraph.

The chromatographic column used was a glass tube, of approximately 4 mm. diameter and 4 ft. long, packed with about 6·5 gm. of activated carbon (Sutcliffe, Speakman No. *B*–206) ground to 30–70 mesh. Both the chromatographic column and the ionization chamber were enclosed in a heating jacket with temperature-control equipment which maintained the temperature at 50 ± 0·5° C. to ensure the stability of the chromatographic sorption processes. The rate of flow of the carrier argon has been fixed at 46 ml./min., which required an input pressure of 230 mm. mercury. Samples of 5 or 10 ml. of gas under investigation were measured under atmospheric pressure by hypodermic syringe and were introduced to the flow of carrier argon through a rubber serum cap on the top of the column.

Some preliminary observations have been made of the biochemical reduction of carbon dioxide to methane during anaerobic fermentation. Volumes of 2·5 l. of fully digested sewage sludge were placed in 10-l. reacting bottles supported with their axes horizontal on rubber-covered rollers. These reactors were fitted with 'Perspex' stationary stirrers and continuously rotated at about 7 rev./min. A rubber cap, acting as a valve, allowed gas exchanges, pressure measurements and the withdrawal of gas samples using hypodermic needles. The reactors were installed in a room in which the temperature was maintained at 32–33° C. with the aid of a thermostatically controlled heater and fan. Digested sludge was gassed by a mixture containing approximately 50 per cent carbon dioxide (by volume) and about 35 per cent hydrogen. A 15 per cent concentration of nitrogen was also present as an indicator since it took no part in the reaction. At the start the total gas pressure was about 30 mm. mercury above atmospheric. Biochemical hydrogen uptake diminished this pressure at the rate of 50–70 mm. mercury per day, which was dependent on the stage of the fermentation process. When necessary, every two or three days, the pressure in the reactor was restored by introduction of a further volume of hydrogen to give an approximately constant concentration of this gas in the digester. At this stage a sample of the gas was taken for gas-chromatographic investigation.

Fig. 1, which represents a series of such observations, shows that during 30 days of operation carbon dioxide concentration in the gas mixture fell from 50 per cent to about 0·5 per cent. It will be noticed that at about the tenth day methane was present in the reacting gas and that the methane steadily replaced carbon dioxide, increasing to about 50 per cent in the gas mixture.

This dynamic observation suggested the desirability of carrying out gas-chromatographic trials on the kinetics of hydrogen uptake by methane bacteria. At the conclusion of the normal methane fermentation, digested sludge was in contact with fermentation gas composed of approximately 65 per cent methane, 35 per cent carbon dioxide and traces of nitrogen. The addition of about 15 per cent of hydrogen enabled the uptake of hydrogen from this change to be observed by gas chromatography for 90 hr., after which there were no further traces of this gas.

These preliminary observations demonstrate the usefulness of the gas-chromatographic technique for such investigations. It is clear that more detailed studies, including a materials balance, are required for a full elucidation of the kinetics of these reactions.

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'Vapour Toxicity' of Solid Insecticides

When considering the performance of solid insecticides of the chlorinated hydrocarbon type, such as DDT, γ-BHC and dieldrin, a factor frequently considered is the toxic properties of the vapours from crystalline deposits. To assess this factor biologically, both in the laboratory and in the field, the commonest practice is to keep cages holding test insects a short distance from the treated surface. The toxic effect found after such an exposure is generally referred to as the 'vapour toxicity'.

However, calculation of the concentration of the saturated vapours of the insecticides mentioned above made it seem very unlikely, particularly in the cases of dieldrin and DDT, that such concentrations are high enough to cause a noticeable mortality, even of susceptible insects exposed for 24 hr. Using the equation:

$$C = (p/PV_o)M$$

in which p is the vapour pressure of the insecticide in mm. mercury, P is atmospheric pressure in mm. mercury, V_o (the volume of ideal gas) = 22·4 l. atm. mole^{-1}, M is the molecular weight and C the concentration of the saturated vapour in grams per litre, one obtains concentration figures of 0·004, 0·53 and 0·004 μgm./l. for dieldrin, γ-BHC and *pp*-DDT respectively, the calculations being based on the results collected in Table 1. As the *LD*95 for *Drosophila melanogaster* Meig. and *Aedes aegypti* L. is of the order of 0·005 μgm./insect with dieldrin and γ-BHC,

Table 1. Vapour Pressures in mm. of Mercury

Insecticide	Vapour pressure	Temperature	Reference
Dieldrin	$1·8 \times 10^{-7}$	25° C.	1
pp-DDT	$1·5 \times 10^{-6}$	20° C.	2
γ-BHC	$3·0 \times 10^{-5}$	20° C.	3

and 0·05 μgm./insect with DDT, it is not surprising that air virtually saturated with vapours of any of these three insecticides proved to be non-toxic to those insects.

The experiment was arranged as follows: Air was passed through two U-tubes filled with powdered insecticide at a rate of approximately 20 l. in 24 hr. On leaving the first tube, which was kept at a temperature of approximately 80° C., the air would be nearly saturated with insecticide at that temperature; in the second, held at about 18–20° C., the excess insecticide would recondense, leaving the air just saturated at that lower temperature. The vapour was then led through a container held at a temperature of 23–24° C., holding *Drosophila melanogaster* and *Aedes aegypti*. At this temperature the vapour is thus just not saturated. No deaths were observed among insects exposed in this way for 24 hr.

Further investigations have shown that the toxic effect often observed in experiments estimating vapour toxicity is mainly caused by insecticide acquired by the insects in an indirect way, namely, via a condensed film formed on the body of the holding cage. It is thought that appreciable condensation will take place only in a system containing saturated vapour and not in the system described above. The following experiments demonstrate the condensation phenomenon in systems with saturated vapours.

Some 10 mgm. of crystalline insecticide was evenly distributed over the bottom of a Petri dish from a solution in hexane. After evaporation of the solvent, this dish was covered by a sheet of filter paper which was larger than the rim of the dish, and covered by a second, untreated dish placed upside down on the filter paper. Care was taken that neither the filter paper nor the top dish was contaminated during this procedure. Remaining in this position overnight, the filter paper and the top dish were then separated from the dish holding the insecticide. *Drosophila melanogaster* were then exposed to the filter paper (both sides) and the top dish, the result being complete kills in all cases. Exposing metal, plastic and muslin fabric in a similar way also gave high kills of *Drosophila melanogaster* exposed to the condensed films.

The actual amounts condensed on the glass were estimated as follows: the top dishes of the combinations just mentioned (without filter paper this time) were exposed over-night to vapours from the insecticide in the bottom dish. The top dish was then removed and the condensed insecticide dissolved in hexane and dilutions of it applied on to the bottom of clean Petri dishes. Houseflies (*Musca domestica* L.) were exposed to the dry residue and the results compared with those obtained simultaneously with known amounts of insecticide. In this way the condensates of dieldrin were found to amount to a little more than 1 μgm./dm.²; the condensates of DDT and γ-BHC were of the order of a few μgm./dm.². The condensates actually found on an area of 1 dm.² contained, except in the case of DDT, sufficient insecticide to give a complete kill of 20 female houseflies exposed for 24 hr. With more susceptible insects such as *Drosophila melanogaster* and *Aedes aegypti*, complete mortality was also obtained with DDT.

It can be concluded from this that, in closed systems, the vapours of DDT, γ-BHC and dieldrin may condense on various materials in concentrations of a few μgm./dm.²; this is sufficient to kill susceptible insects. The consequence is that where cases in the literature in general do refer to the 'vapour effect', in fact the effect is of such surface deposits of condensed vapour plus the effect of an eventual condensate directly on the insect.

It need not be stressed that this condensation can be influenced by a great number of variables, and thus that the results provided are of highly questionable value.

Thanks are due to the management of 'Shell' Research, Ltd., for permission to publish this work.

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Moisture Content of Whole Bread and Bread Crumb

In order to secure that bread is properly baked, the statutory regulations and laws prescribe maximum permissible moisture content of the baked product. In some countries the law is based on the water content of the whole loaf; in others the maximum permissible moisture content of the crumb only is laid down.

In order to compare the value of these methods in judging proper bread baking, the following sets of experiments were made (in each case with both white and high-extraction flour).

(*A*) Three pieces from one dough were scaled at 580 gm. each, fermented, panned and baked to variable final weight; (*B*) three doughs of various consistencies, and water contents, were scaled at 580 gm. and baked to a weight of 500 gm. in each case.

In all loaves the moisture content of the whole loaf and of the crumb only was determined.

Table 1. Moisture Content of Bread and Bread Crumb

No.*		Weight of baked bread (gm.)	Moisture of crumb (per cent)	Moisture of whole bread (per cent)
A	1	520	45·6	40·8
	2	500	45·4	38·4
	3	481	44·8	36·2
	4	520	45·8	41·0
	5	500	45·8	39·1
	6	480	45·9	36·0
B	7	500	46·1	39·5
	8	500	45·1	37·9
	9	500	44·6	37·6
	10	500	46·2	39·8
	11	500	45·9	37·8
	12	500	44·8	37·3

* 1–3, 7–9, dark wheat bread; 4–6, 10–12, white bread.

The results (Table 1) seem to show that prolonged baking has little, if any, influence on moisture content of the crumb, and that the latter is rather a measure of water content of dough from which the bread was baked than a criterion of adequate baking and proper crust formation.

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PHYSIOLOGY

Excretion of Catechol in Human Urine

DURING a study of the catechol compounds in human urine it was observed that acid hydrolysis (20 min., 1 *N* sulphuric acid, 100° C.) caused a large increase in the content of some catechol compounds, presumably by splitting of a conjugate[1]. Chromatographic separation of the different catechols obtained by adsorption on alumina of hydrolysed urine indicated that the large increase was connected with a catechol compound having a rate of flow similar to that of 3,4-dihydroxyphenyl acetic acid in a solvent system of *n*-butanol–hydrochloric acid–acetic acid[2].

Further analysis of the chromatographically separated fractions revealed that the catechol compound differed from 3,4-dihydroxyphenyl acetic acid in its migration pattern in different systems. From its position on paper when butanol–hydrochloric acid and *m*-cresol–acetic acid–water[3] were used as solvents, and by the colour observed on spraying with ferricyanide or ferric chloride, the compound was identified as catechol itself, Fig. 1. This conclusion was further corroborated by colour reactions in solution after addition of ferric chloride, by separation with ion-exchange resins and by fluorescence curves in the spectrophotofluorimeter.

The appearance in urine of a conjugate with sulphuric acid after ingestion of catechol in dogs was shown by Baumann[4] who also claimed that human urine may contain this compound. More recently, Fiker[5] has reported that hydrolysed normal urine contained 5 mgm. catechol per litre.

The amounts of catechol found in five samples of normal human urine after acid hydrolysis varied between 46 and 108 μgm./hr., and was on an average 82 μgm./hr.

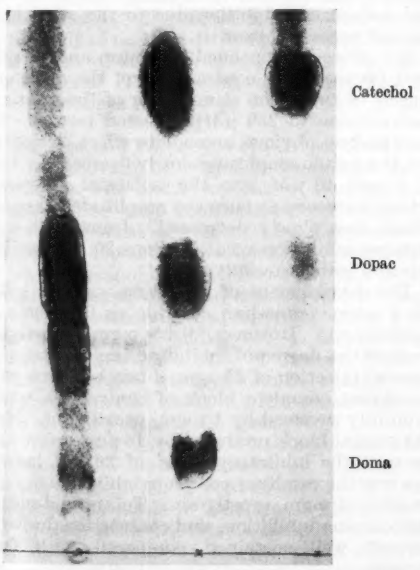

Fig. 1. Paper chromatogram, Whatman No. 1, *m*-cresol–acetic acid–water. (I) Fractions 8·8–13·2 ml. from column chromatogram of unhydrolysed normal human urine, adsorbed on alumina, solvent *n*-butanol–hydrochloric acid–acetic acid–water; (II) standards, catechol, dopac (3,4-dihydroxyphenylacetic acid); doma (3,4-dihydroxymandelic acid); (III) same as I but urine treated with 1 *N* sulphuric acid, 20 min., 100° C. before adsorption. In III about one-fifth of amount of urine in I

No evidence for the presence of catechol in unhydrolysed human urine was obtained. Catechol was also found in cow's urine after hydrolysis.

The origin and formation of the catechol are at present being studied.

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Mechanism of Action of Insulin

EXPERIMENTS have been carried out to determine to what extent insulin lowers the glucose concentration in the plasma by increasing glucose utilization by the tissues and to what extent by diminishing glucose production by the liver.

Trained dogs were used in the post-absorptive state and without anæsthesia. The size of the body glucose pool and the rates of glucose production and utilization in the resting state and during periods of changing blood glucose concentrations were determined by the use of an isotope dilution technique using ^{14}C-glucose[1-3]. The body glucose pool was labelled by a priming injection of a trace amount of uniformly labelled ^{14}C-glucose. The established specific activity was maintained for several hours by a constant infusion of a trace amount of glucose labelled with carbon-14 which balanced the endogenous ^{12}C-glucose output by the liver, provided this output remained constant[1]. After the radioactive glucose had been infused for 2 hr., trypsin-treated crystalline insulin (low in glucagon content; Lilly) was administered in one of the following ways, while the labelled glucose infusion continued uninterrupted: (*a*) single intravenous injection; (*b*) continuous intravenous infusion; (*c*) subcutaneous injection. Samples of blood were collected at intervals and the plasma glucose concentration and specific activity were determined. From these results the glucose production and utilization were calculated[1,3].

It was previously shown[3] by use of this technique that when insulin is administered as a single intravenous injection the resulting hypoglycæmia is due mainly to an increased uptake of glucose by the tissues. The initial transient diminution of glucose release from the liver which was often observed was a relatively minor factor in the development of the hypoglycæmia. The return of the glucose concentration in the plasma to the control value was found to be brought about by a sudden increase in the release of glucose from the liver in response to the hypoglycæmia.

In the present studies insulin was introduced into the jugular vein through a polyethylene tube by means of a constant infusion pump. The insulin dosage varied from 0·1 to 0·25 U./kgm., infused in 90 min. In each case a hypoglycæmia developed which persisted throughout the period of insulin infusion. As shown by the relatively unchanging level of specific activity of plasma glucose the hypo-

glycæmia was due almost entirely to increased utilization of glucose, the glucose production remaining at about the pre-insulin level. Cessation of glucose production was never observed.

In order to determine whether physiologically secreted endogenous insulin lowers the blood sugar by the same mechanism as exogenous insulin, the secretion of insulin by islet tissue was provoked by the administration of a glucose load. The experiments were designed to provide a more adequate test than similar experiments which were reported recently[4] in which smaller glucose loads were injected in anæsthetized dogs. The body glucose pool was labelled with ^{14}C-glucose and the specific activity was maintained by a constant infusion of labelled glucose as described above. At 2 hr. a glucose load sufficient to maintain a hyperglycæmia for 45–60 min. was administered. The glucose load had the same specific activity as the glucose already circulating in the plasma. Infusion of the trace amount (less than 2 mgm./hr.) of labelled glucose was continued uninterrupted throughout the experiment. As shown by the unchanging specific activity of plasma glucose, glucose production by the liver continued during hyperglycæmia at the same rate as before the glucose load was given. The rate of glucose utilization during the hyperglycæmia was always greatly increased.

Thus it appears that physiologically secreted insulin, like administered exogenous insulin, lowers the concentration of blood sugar almost entirely by increasing utilization of glucose.

An additional finding, possibly of considerable importance, was made with regard to the restoration of the level of blood sugar after insulin-induced hypoglycæmia. The restoration of the level of blood sugar to normal, following a single intravenous injection of insulin, begins at about the lowest point of the glucose concentration curve, at which time a marked increase in glucose production occurs rather suddenly[3]. In the case of the experiments involving prolonged (90 min.) insulin infusions, this extra glucose output in response to hypoglycæmia occurred only after termination of insulin infusion, whereupon again it occurred rather suddenly and restored the blood sugar to normal.

Thus although insulin brings about hypoglycæmia primarily by increasing uptake of glucose and not by decreasing hepatic glucose output, the presence of newly injected exogenous insulin affects the animal in such a way that it fails to increase its hepatic glucose output in response to hypoglycæmia.

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Action of Pyrrolizidine Alkaloids on the Neuro-Muscular Junction

Median lethal doses of the plant pyrrolizidine alkaloids, heliotrine and lasiocarpine, have been determined by Bull *et al.*[1]. Deaths occurred from hepatotoxic effects except in some female rats given heliotrine.

The present study showed that injection of larger doses than the *LD*50 of the alkaloids, but not of their N-oxides, produced progressive muscular weakness, respiratory distress and death from respiratory failure within 30 min., suggesting the occurrence of a neuro-muscular block.

Rat phrenic nerve-diaphragm preparations were made by the method of Mogey *et al.*[2]. N-oxides of the alkaloids did not affect transmission of impulses or contraction in such preparations. However, small doses, 1–6 μM/ml., of heliotrine or of lasiocarpine first potentiated then blocked the diaphragmatic response to phrenic nerve stimulation. The lowest effective doses increased the amplitude of the contractions. With slightly higher concentrations, the initial increase in amplitude was followed by partial but progressive inhibition of contraction. Larger doses immediately inhibited contraction and rapidly led to complete inhibition. Lasiocarpine was effective in lower concentrations than heliotrine.

During complete block, the muscle responded normally to direct stimulation. Also the addition of these alkaloids to the nerve bath only, did not affect impulse transmission. The effect of the alkaloids is thus localized at the neuro-muscular junction. The block was reversed by washing the preparation free of alkaloid. However, despite the apparent complete reversal, subsequent doses of either alkaloid were potentiated. Neither prostigmin nor pentamethonium influenced inhibition due to the alkaloid or the rate of recovery from it.

The procedure outlined by Paton and Zaimis[3] was used for recording contractions of the anterior tibial muscle of cats upon stimulation of the sciatic nerve. Lasiocarpine (5–250 μM), injected into the femoral vein had no obvious immediate effect on contraction but the twitch amplitude slowly decreased. Injection of 5 and 10 μM into the isolateral anterior tibial artery increased at once the amplitude of contraction which then slowly decreased. Immediate and progressive inhibition resulted from 20 μM lasiocarpine injected intra-arterially.

The development of inhibition was not influenced by 3 mgm. potassium chloride or 0·5 mgm. pentamethonium. However, 0·25 mgm. prostigmin increased the degree of inhibition immediately. Intra-arterial injection of 25 μgm. *d*-tubocurarine produced an almost complete block of contraction which was promptly reversed by 1 mgm. prostigmin. However, the partial block produced by 15 μgm. curare did not prevent the inhibitory effect of 20 μM lasiocarpine nor was the resultant complete inhibition antagonized at all by 1 mgm. prostigmin. Tetany did not remove lasiocarpine inhibition, and contraction during tetany seemed well sustained compared with curarized muscle.

The alkaloids did not inhibit cholinesterase or the activation of acetate. The possibility of an effect on the succeeding step of acetylcholine synthesis will be investigated.

Present knowledge seems inadequate to separate agents which block impulse transmission at neuro-muscular junctions into discrete groups. With

reference to the differences drawn between decamethonium-like (C_{10}-like) and *d*-tubocurarine-like compounds by Paton and Zaimis[3], the pyrrolizidine alkaloids have resemblances to, and differences from, both groups. They resemble C_{10} in the enhancement of muscle contraction in low concentrations, the failure of inhibited preparations to respond to potassium chloride, the increased inhibition resulting from prostigmin administration, the relatively well sustained contraction during tetany and failure to recover from inhibition after tetany; but they differ in the inability of the prior injection of curare to antagonize alkaloid inhibition and the failure of pentamethonium to reverse the inhibition.

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Hæmoglobin of New-born Infants in Indonesia

STUDIES on the hæmoglobin of new-born infants, including electrophoretic examinations, have been carried out by several workers. Normally, the red blood cells of new-born infants contain two types of hæmoglobin, fœtal hæmoglobin (Hb *F*) and normal hæmoglobin (Hb *A*). The fœtal hæmoglobin, which is resistant to alkali and has a different electrophoretic behaviour from that of normal adults, is the major component. The amount of hæmoglobin *F* in cord blood ranges from 50 to 90 per cent of the total.

In 1957, Fessas and Papaspyrou in Greece found an unusually fast-moving hæmoglobin component in a new-born infant who had symptoms of thalassæmia and whose parents were thalassæmics[1]. Nanakorn, in Thailand, reported a fast-moving hæmoglobin component in the blood of a new-born baby which she thought was hæmoglobin *H*[2]. However, this component has never been compared with the fast-moving hæmoglobin of Fessas and Papaspyrou. Agar and Lehmann reported the finding of a fast-moving hæmoglobin in a new-born baby of Chinese–Negro–Spanish–English origin, which the authors called the 'Bart's' hæmoglobin and which at *p*H 8·6 was slightly faster than that of Fessas and Papaspyrou[3].

I have continued my previous studies on the hæmoglobin of new-born infants[4,5] by making a survey of the hæmoglobin of cord blood of new-born infants in three hospitals in Djakarta. The hæmoglobins prepared from the blood samples were all examined electrophoretically by the paper electrophoretic method of Smith and Conley[6]. In many the amount of hæmoglobin resistant to alkali was estimated by the method of Singer *et al.*[7].

A total of 1,138 samples of blood was examined. 633 samples were from Chinese and Indonesian Chinese, 480 from Indonesians, 22 from Indonesian–Dutch infants, and three of other nationalities. The great majority of the samples contained normal and fœtal hæmoglobin, the alkali-resistant hæmoglobin being the major component. However, in several of the samples, a third component was present. In this material there were two kinds of an unusual third component. The first was a slow-moving hæmoglobin, while the other was a fast-moving one.

The slow-moving component at *p*H 8·6 migrated slightly faster than hæmoglobin *E* on horizontal paper electrophoresis. It was present in small quantities. Among the 633 Chinese infants (Chinese and Indonesian–Chinese), one carried this hæmoglob in in the cord blood, while the blood of 2 out of 480 Indonesian new-born babies were found to contain this component. Of the 17 Indo–European babies, one had this hæmoglobin at birth. In two of the four infants who carried a slow-moving hæmoglobin (one Indonesian and one Indo–European baby), this component was thought to be hæmoglobin *E*, because both parents could be examined and in both one of the parents had hæmoglobin *E*. The slight difference in migration-rate may be due to the relatively small amount of this hæmoglobin present. Previously[5,8] I described the postnatal formation of hæmoglobin *E* in several infants but it was not found at birth. I also noted at that time, that, when the component started to appear in the blood in a very low concentration, it migrated, at *p*H 8·6, slightly faster than hæmoglobin *E*. After some time, when the child was older, the component was present at a higher concentration. It then had exactly the same mobility as the hæmoglobin *E* in the mother. It seems from the findings in this communication that in a small proportion of hæmoglobin *E* trait carriers the hæmoglobin *E* is already detectable at birth. In the other two infants who had a slow-moving component it cannot be said that this was probably *E*, because the parents could not be examined.

The other abnormal third hæmoglobin, which was present in several of the cord-blood samples, was a fast-moving one, at *p*H 8·6 was much faster than hæmoglobin *A*, had about the same mobility as hæmoglobin *J*, but was definitely slower than *H* (Fig. 1). At *p*H 6·5 it was definitely less anodic than hæmoglobin *H*, which migrated clearly to the positive pole (Fig. 2). This hæmoglobin resembled the one

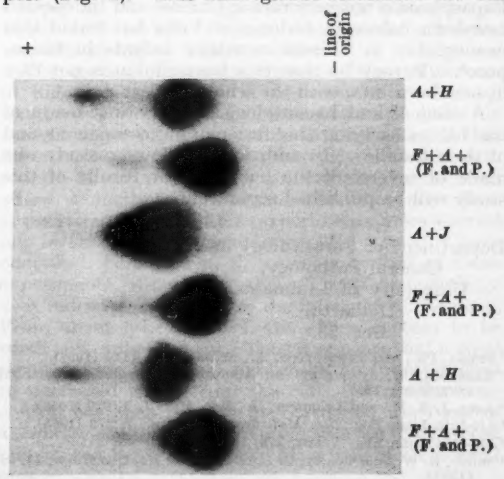

Fig. 1. Paper electrophoresis at *p*H 8·6 of the hæmoglobin of Fessas and Papaspyrou (F. and P.) in new-born babies compared with hæmoglobins *H* and *J*

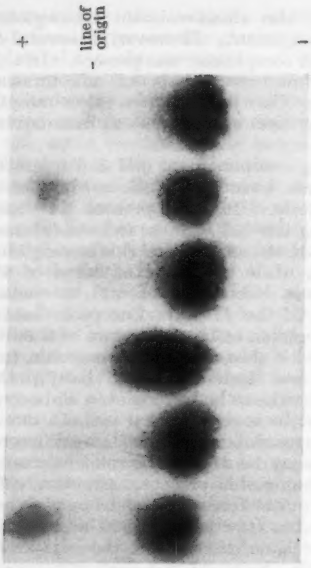

Fig. 2. Paper electrophoresis of the same hæmoglobins as in Fig. 1 at *p*H 6·5

described by Fessas and Papaspyrou in its mobility at acid as well as at alkaline *p*H. I therefore sent a sample to Dr. Fessas, who confirmed our findings and found that it was similar to that described by him and Dr. Papaspyrou. This hæmoglobin is not very stable. When kept in the refrigerator it disappeared after some time, but was more stable when frozen. It did not give rise to intracellular crystal formation in erythrocytes after several hours incubation in brilliant cresyl blue and therefore differed also in this respect from hæmoglobin *H*. A total of 23 samples was found to contain this fast-moving hæmoglobin : 21 in Chinese (among 633 samples) and 2 in Indonesian babies (among 480 samples). The parents of these babies do not have any abnormal hæmoglobin.

It seems that the hæmoglobin of Fessas and Papaspyrou is not very rare in Chinese and Indonesian new-born babies in Indonesia. Vella has found this hæmoglobin in Chinese new-born infants in Singapore[9]. It may be that this hæmoglobin is not rare in new-born infants in the whole of East Asia.

A clinical and hæmatological study was made of the babies carrying this fast-moving component and of their families. In addition, a follow-up study was made of several of the babies. The results of this study will be published separately.

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Effect of Toxopyrimidine on Glutamic-decarboxylase and Glutamic-oxalacetic Transaminase of Rat Brain

In a previous communication Rindi and Ferrari[1] reported a statistically significant decrease of γ-aminobutyric acid in the brain of rats treated with a structural pyridoxamine antagonist having an epileptogenic action, namely, 2-methyl,4-amino,5-oxymethylpyrimidine (toxopyrimidine). In this communication we wish to report results obtained in an enzymatic study of the action of toxopyrimidine. We determined the glutamic decarboxylase and glutamic-oxalacetic transaminase (both pyridoxal-phosphate linked enzymes) in the brain of rats with epileptic seizures caused by injection of toxopyrimidine, and of rats restored to normal with pyridoxamine.

The experimental conditions were as previously described[1]. Toxopyrimidine and pyridoxamine were injected intraperitoneally : at doses of 125 μgm./gm. and 62 μgm./gm. respectively.

Glutamic-decarboxylase activity was evaluated[2] by determining by paper chromatography[1] the increase in the formation of γ-aminobutyric acid in brain homogenate after the addition of glutamic acid (Table 1). Glutamic-oxalacetic transaminase was determined by the colorimetric method by Tonhazy, White and Umbreit[3] with minor modifications[4].

Table 1. Glutamic-decarboxylase and Glutamic-Oxalacetic Transaminase Activities of Brain of Rats treated with Toxopyrimidine (Mean ± Standard Error)

Glutamic-decarboxylase activity			Glutamic-oxalacetic transaminase activity		
No. of animals	Condition	Increase in γ-amino-butyric acid production (μgm.)*	No. of animals	Condition	$Q_{T^{38}}$†
10	Treated	184·7 ± 9·2	12	Treated	217 ± 4·8
8	Controls	232·2 ± 10·4	13	Controls	227 ± 8·0
11	Normals	238·5 ± 7·9	8	Normals	233 ± 13·3
6	Treated + vitamin B_6 3½ hr. after pyridoxamine	224·2 ± 9·8			
4	Treated + vitamin B_6 6 hr. after pyridoxamine	247·5 ± 7·9			

* Reaction mixture, in phosphate buffer 0·05 *M*, *p*H 6·2 : (*a*) 2 ml. homogenate containing 250 mgm. of tissue + 0·5 ml. *l*-glutamic acid. 0·62 *M*, *p*H 6·2 ; (*b*) 2 ml. homogenate + 0·5 ml. phosphate buffer. The increment is calculated by subtracting the γ-aminobutyric acid content in (*b*) from (*a*).

† $Q_{T^{38}}$, μl.CO_2/mgm. dry tissue per hour (see ref. 3).

The results summarized in Table 1 show a statistically significant ($t = 3{\cdot}412$; $0{\cdot}01 > P > 0{\cdot}001$) inhibition of glutamic decarboxylase activity in the epileptic brain in comparison with control (and normal) animals.

3½ hr. after the injection of pyridoxamine, which quickly abolished epileptic seizures, the inhibition was completely eliminated. Since the decrease of decarboxylase activity (20·4 per cent) was of the same order[1] as the decrease in cerebral γ-aminobutyric acid (23·3 per cent) after injection of toxopyrimidine, we can assume that the two results are closely related. On the other hand, no modification in cerebral glutamic oxalacetic transaminase activity after administration of toxopyrimidine was apparent. Killam and Bain[5] reported similar results using convulsant hydrazides. They suggested that pyridoxal-phosphate is more

firmly bound to the apoenzyme in the transaminase than in the decarboxylase[6,7].

Our results support the views of Tower[8], who recently emphasized the importance of the glutamic acid–γ-aminobutyric acid system in neuronal function, and the close connexion between glutamic decarboxylase inhibition and the onset of epileptic seizures in dietary or antimetabolite pyridoxine deficiency.

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Effect of Ouabain on Sodium Flux in Human Red Cells

It has been shown that the cardiac glycosides inhibit the transport of cations in human red cells[1–3], and it appears that this effect is exerted directly on the transport mechanism rather than on its energy supply[3–5]. Though some studies of the effect of these drugs on transport of sodium have been made, interest has been centred on the inhibition of transport of potassium. The present communication is concerned with the relationship between the sodium and potassium fluxes in human red cells treated with the cardiac glycoside, ouabain.

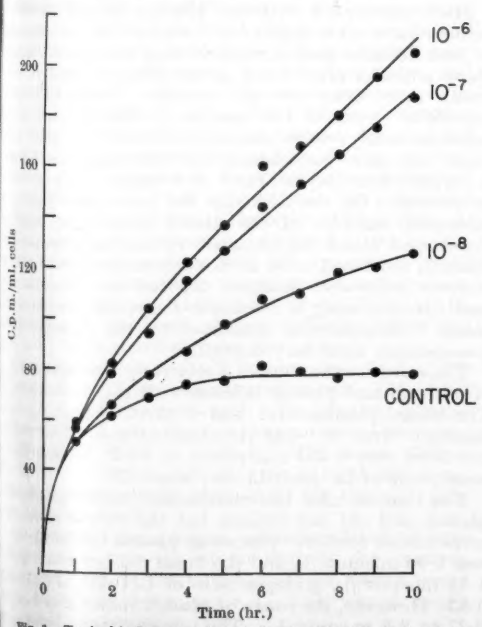

Fig. 1. Typical influx experiment showing the effect of ouabain on accumulation of sodium. Sodium chloride labelled with sodium-24 was added to fresh, heparinized human blood (relative cell volume, approximately 45 per cent)

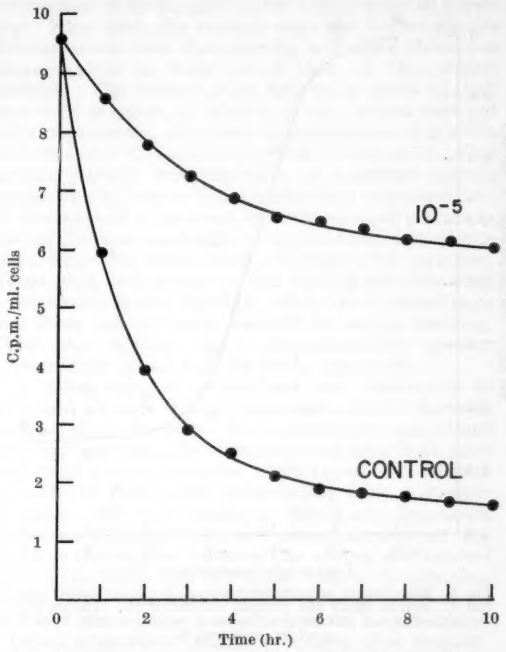

Fig. 2. Typical efflux experiment showing the effect of ouabain on sodium efflux. Fresh, heparinized human blood was incubated with labelled sodium chloride for 1 hr. The radioactive cells were separated and added to a non-radioactive, plasma-like, isosmotic medium to produce a mixture with a relative cell volume of approximately 45 per cent

Influx and efflux experiments have been carried out at 37° C. on fresh, heparinized, whole human blood using sodium chloride labelled with sodium-24 and the methods previously described[2,6]. Fig. 1 shows the results in a typical influx experiment. The concentration-range covered in eight such experiments was 10^{-4} to 10^{-11} mole ouabain/l. blood. These experiments indicate that inhibition is slight at concentrations between 10^{-11} and 10^{-9} mole/l. It increases sharply at 10^{-8} and appears to reach saturation at about 10^{-6} mole/l., though results are somewhat variable at higher concentrations.

This marked effect may represent either an increase in influx of sodium-24 or a decrease in efflux of sodium-24, since either process would result in accumulation of radioactivity in the cells. Efflux experiments (in which cells previously incubated with sodium-24 are placed in a non-radioactive medium) afford a method of discrimination between these alternatives. Four efflux experiments were carried out in the concentration-range of 10^{-5} to 10^{-7} mole ouabain/l. blood. Fig. 2, which is typical of these experiments, shows that the efflux of radioactivity does indeed decrease under the influence of the drug. From about 6 hr. onward, the efflux appears to be small and quite uniform. Thus it appears that a large portion of the gain in cell sodium-24 may be attributed to decreased efflux from the cells. A similar conclusion has been reached by Glynn[9] on the basis of a comparison of influx experiments on cold-stored human red cells with efflux experiments on normal ones.

The results for net gain of sodium may be compared with the net loss of potassium as previously measured under similar experimental conditions[9]. These

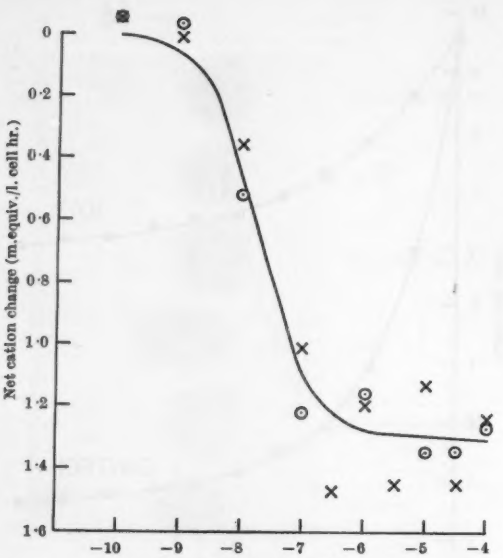

Fig. 3. Relationship between net cation shift (×, potassium loss and ○, sodium gain) and ouabain concentration. The results for potassium loss and the dose response curve are taken from a previous paper (ref. 2)

results are shown in Fig. 3, in which the dose response curve is that previously obtained for potassium. It can be seen that there is no demonstrable difference between gain of sodium and loss of potassium as ouabain concentration is varied over a million-fold range. 50 per cent inhibition of the affected potassium influx (which is about 80 per cent of the total potassium influx) was reached at an ouabain concentration of $3{\cdot}2 \times 10^{-8}$ mole/l. Since the curve describes the effect on sodium as well as that on potassium, the same half-inhibition value is reflected in the accumulation of sodium.

These experiments show a 1 : 1 correspondence between downhill net movements, that is, sodium influx and potassium efflux, when transport is maximally inhibited by ouabain. This makes it difficult to believe that the movement of these ions is not regulated by a common mechanism, since the electrochemical driving force is different for each cation. The correspondence is also apparent at the 50 per cent inhibition point, when processes of uphill and downhill transport both participate. Certainly, these observations could be used for supporting the proposal of Harris and Maizels[7] that red-cell sodium and potassium transport systems are linked. Glynn[8] has also reached the conclusion that there is a 1 : 1 linkage between 'active' sodium efflux and 'active' potassium influx. (Post and Jolly[9] have studied uptake of potassium by cells that have been stored at 2° C. for periods up to 25 days. They also find a linkage, 2 atoms of potassium being transported inwards for every 3 atoms of sodium transported outwards. These studies are not comparable with the present ones, since the cells had been stored for many days and their internal cation concentrations were very different from normal.) Glynn's conclusion depends upon studies of glucose-sensitive fluxes in cells suspended in a medium containing almost no potassium. These fluxes include only about half the total sodium flux; an appreciable fraction of the remainder, according to Glynn, moves by the process of exchange diffusion. The present results are compatible with those of Glynn, though ouabain may affect both Glynn's 'active' sodium efflux and the exchange diffusion process. Since ouabain apparently does not affect the supply of energy, but is presumed to act on the transport mechanism, the present results suggest that the linkage is effective at a step beyond supply of energy, probably at the cell surface, on the sites assumed important for the first step in entrance of potassium into the cell[2]. However, in both Glynn's and the present work, linkage has been demonstrated in cells that have been subject to a perturbation, such as deprivation of extracellular potassium, or the addition of ouabain. Thus, caution must be used in interpreting such observations as illustrative of the normal transport of ions across the red-cell membrane.

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Lithium Retention in Ascites Tumour Mice

Mice inoculated with an Ehrlich Lettré ascites tumour have a life-span of 2–3 weeks. In the course of ionic balance studies on such mice we noticed that these animals, after being given lithium, tended to retain more than normal controls. Daily lithium injections (1 ml. of 150 m.equiv./l. lithium chloride subcutaneously) were started on either the fifth or tenth day after inoculation, and were continued for a further four days. Food and water were given *ad libitum*. On the fifth day the mice were lightly etherized, samples of the ascitic fluid were withdrawn and blood was obtained by cardiac puncture. Plasma, red blood cells, ascites supernatant fluid and tumour cells were analysed for sodium, potassium and lithium using a Beckman flame spectrophotometer. All mice were examined for the presence of macroscopic secondary deposits.

The control mice showed a relatively constant level of red-cell and plasma lithium with this treatment. The mean plasma-level was 0·23 m.equiv./l. ± a standard error of 0·013 (15 observations). The red-cell level was 0·434 m.equiv./l. ±0·022. Thus the mean ratio of Li+(out)/Li+(in) was 0·53.

The tumour mice had consistently higher levels of plasma and red cell lithium but the results showed considerable scatter. The mean plasma lithium-level was 0·96 m.equiv./l., and the mean red-cell level was 1·15 m.equiv./l., giving a ratio of Li^+(out)/Li^+(in) of 0·83. However, the range of plasma values was from 0·27 to 2·8 m.equiv./l. The lowest plasma-level in the ascitic mice was higher than the mean control level, but we feel that the tumour mice cannot be

regarded as a homogeneous population. The overall plasma to cell ratio was higher in the tumour mice than in the controls, but it was noted that where the plasma lithium-level was low the tumour mice showed a ratio similar to the controls, and as this level rose the ratio rose.

The lithium-level of the supernatant fluid obtained by centrifuging the ascites contents was very similar to that of the plasma in the same mouse. The lithium-content of the tumour cells was the same as, or slightly less than, the supernatant level. The cells appear to contain large amounts of lipid material which may complicate the estimate of ionic distribution between cells and supernatant.

The amount of trapped fluid remaining in the cell mass after 60 min. centrifugation of the ascites contents at 1,150*g* was estimated using radio-iodinated serum albumin, and was found to be 20–24 per cent of the total mass. This figure is somewhat greater than that found by Maizels *et al.*[1].

The mean sodium-content of the tumour cells was 75·6 ± 2·3 m.equiv./kgm. (25 observations). The mean sodium-level of the supernatant was 149 ± 2·0 m.equiv./l. and from this figure and the estimate of the trapped fluid the intracellular sodium-level was calculated to be 54 m.equiv./l. The mean potassium-level of the cells was 73·0 ± 3·1 m.equiv./l. (25), and the potassium-level of the supernatant fluid, which was very variable, gave a mean value of 18·5 m.equiv./l. Thus the intracellular potassium-level was estimated as 88·5 m.equiv./kgm. These figures are noticeably different from those found for the red-blood cell.

It will be noted that the mean supernatant fluid sodium-level is 15 m.equiv./l. lower and the mean potassium-level is 13 m.equiv./l. higher than the corresponding plasma figures. These differences may be due to ionic movements along the respective concentration gradients between the time of removal of the ascites fluid from the animal and its separation by centrifugation. This was checked in one animal by removing ascites fluid, immediately filtering some of it through a Whatman No. 42 filter paper and centrifuging the rest in the usual manner. The filtered cell-free fluid had a potassium concentration of 5·4 m.equiv./l., the same as plasma, whereas the centrifuged supernatant fluid had a potassium concentration of 7·7 m.equiv./l. This particular ascites had a cell content of 10 per cent so that the potassium leakage from the cell was of the order of 20 m.equiv./l. of the initial cell potassium. As most of the ascites in the experimental series had cell contents of 30–50 per cent the discrepancy between the supernatant fluid and plasma potassium-levels is likely to be explicable on the basis of ionic diffusion across the cell wall after removal from the animal.

The crude mean red-cell sodium was 24·4 ± 1·7 m.equiv./l., and the plasma sodium was 164 ± 2·2 m.equiv./l. (18 observations). The trapped plasma volume was 3 per cent, giving a corrected intracellular level of 21 m.equiv./l. The mean plasma potassium-level was 5·3 m.equiv./l., and the mean corrected intracellular potassium for the red cells was 123 m.equiv./l.

In general, the plasma potassium-level of the tumour mice was similar to that of the controls except in mice in the terminal stages, where levels were as high as 9·0 m.equiv./l. This was probably an agonal phenomenon.

Further experiments were carried out in which lithium was added to the drinking water at a concentration of 30 m.equiv./l. for 4 days prior to bleeding. Here again the tumour mice had higher plasma lithium-levels than the controls, and again there was more scatter in their levels than in the control animals. The control mice had mean levels of 0·77 and 0·66 m.equiv./l. lithium in the plasma and red cells respectively, compared with corresponding levels of 1·52 and 1·72 m.equiv./l. in the tumour mice. One cannot exclude the possibility of a greater lithium intake by the tumour mice in this type of experiment. It is noteworthy, however, that the ratio of plasma to red-cell lithium was higher in all drinking experiments than when the mice received lithium by injection. These mice had access to the lithium solution until immediately before bleeding, while the injected mice had their last injection some 20 hr. before bleeding. Thus the finding of a proportionately greater extracellular phase may be easily explicable.

A third type of experiment was performed to ascertain whether lithium treatment altered the ionic content of the tumour. Twelve mice were inoculated with the same sample of tumour and four days later half were given a solution of 25 m.equiv./l. lithium chloride to drink. All were killed after a further six days. We were unable to detect any significant difference in the sodium and potassium-level of the blood or the tumour between the control and treated mice. The latter had the usual lithium distribution. Under these conditions lithium does not appear to alter the ionic balance of the tumour mouse.

Given a constant intake it is clear that tumour-bearing mice retain more lithium over a period than normal controls. This must be a reflexion of decreased renal excretion in the tumour-bearing animals. It is not possible to decide from this work whether the retention of lithium is a specific renal effect, possibly hormonal, exerted by the tumour, or whether it is merely due to the mechanical effect of the accumulating ascites on the kidney. It may be that renal blood flow is greatly reduced in these animals.

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Oxidative Metabolism and Puparium Formation in the Ebony Mutant of *Drosophila melanogaster*

We have recently reported[1] differences between the oxidative metabolism of the wild type and the ebony mutant of *Drosophila melanogaster*. (The latter has a paler and softer puparium than the wild type.) As it was found earlier[2] that dehydrogenase activity of homogenates of prepupæ at the time of pupation is 26 per cent higher in ebony than in the wild type (reciprocal values of the average decoloration time, given by homogenates of 10 prepupæ in 0·2 ml. 0·02 per cent methylene blue: 0·0469 for ebony, 0·0346 for wild), while the oxygen consumption of intact prepupæ at the same stage is only 18 per cent higher in ebony than in the wild type (average oxygen uptake per hour per 1 mgm. dry weight, 4·52 µl. for ebony, 3·71 µl. for wild type; measurements made by Miss Mary Hartman) it was inferred that

during pupation the redox potential is lower in ebony than in the wild type.

As it was reported by Ohnishi[2] that tyrosinase activity at the same time is about twice as high in the wild type as it is in ebony, it was thought that these findings, taken together, support Dennell's concept[4] that tyrosinase activity is controlled by dehydrogenases, which lower the redox potential and thereby inhibit tyrosinase. Karlson and Wecker's results[5], according to which not the dehydrogenase system but rather the activity of the cytochrome system is responsible for keeping tyrosinase activity at bay, was disregarded in view of the higher percentage difference between dehydrogenase activities as compared with the difference between total oxygen consumption of the two types. This failed to take into consideration that dehydrogenase activity and total oxygen consumption are not comparable values, but the former represents only a fraction of the latter.

If we assume that total oxygen consumption is made up of dehydrogenase, cytochrome and tyrosinase activity in the same proportion in *Drosophila* as—according to Karlson and Wecker—in *Calliphora* (at puparium formation roughly half due to tyrosinase activity and a quarter each due to cytochrome and dehydrogenase activity respectively) then the 26 per cent higher dehydrogenase activity observed in ebony prepupæ would account only for a 6 per cent higher total oxygen consumption. But as this value was found to be 18 per cent higher in ebony than in the wild type at pupation, it is to be concluded that a greater part of this 18 per cent difference (roughly about two-thirds, if the ratios are the same as in *Calliphora*) must be due to a higher cytochrome activity and only a small part to a greater activity of the dehydrogenases. This indicates that the concept of Karlson and Wecker (inhibition of tyrosinase by cytochrome respiration, through competition for quinones, which are needed for the induction of tyrosinase activity), rather than the explanation of Dennell (inhibition by dehydrogenase activity and subsequent lowering of the redox potential) is the correct one.

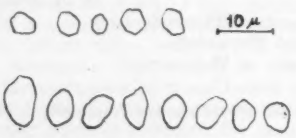

Fig. 1. Outline drawings (camera lucida) of nuclei in the corpus allatum portion of Weismann's ring. Upper row, wild type; lower row, ebony

In any event, the lower tyrosinase activity in ebony, as measured by Ohnishi and manifested in the lack of tanning of the puparium, is associated with a higher rate of respiratory metabolism. We have suggested that this increased metabolism is due to an increased activity of the juvenile hormone, produced by the corpus allatum portion of Weismann's ring, as we found the nuclei of the cells in this portion significantly larger in ebony than in the wild type (Fig. 1), and interpreted this as a sign of greater endocrine activity. The ratio of the average nuclear diameters (4·60μ for wild, 6·25μ for ebony) is almost exactly 3 : 4. Taking into consideration that somatic cells of *Drosophila*, especially those of a glandular nature (like the salivary gland cells), are known to be polytenic in various degrees[6] we venture now to suggest that the primary effect of the ebony gene is perhaps to increase the degree of polyteny in the cells of the corpus allatum portion of Weismann's ring. If this could be proved, one would have an attractive picture of the chain of physiological–biochemical processes leading from the ebony gene to the external character of the pupa, which it controls: (1) increased multiplication of chromonemata in the nuclei of the corpus allatum (either at a faster rate, or by a prolonged period); (2) higher degree of polyteny of these nuclei; (3) increased synthesis of the juvenile hormone; (4) higher rate of respiratory metabolism; (5) greater inhibition of tyrosinase activity; and (6) imperfect ('juvenile') tanning of the puparium.

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Inhibition of Growth and Respiration of *Ophiobolus graminis* var. *avenae* and *Aspergillus niger* by Cystine

The fungus *Ophiobolus graminis* infects the roots of wheat and barley, but does not infect oats. *O. graminis* var. *avenae*, however, infects oats as well. Both strains grow well in a simple medium containing potassium dihydrogen phosphate, sodium hydrogen phosphate, magnesium sulphate, glucose, thiamin, biotin, and a nitrogen source, usually ammonium nitrate or sulphate, or amino-acids. Most of the amino-acids give good growth when used singly as sole nitrogen source. Growth of *O. graminis* is stimulated by cysteine and cystine added to the basic medium containing ammonium nitrate up to a concentration of 0·01 *M*. Without an inorganic nitrogen salt, growth is very good with 0·04 *M* cysteine. Growth of var. *avenae* is inhibited by cystine and cysteine at concentrations as low as 10^{-6} *M* and at no concentration is growth stimulated[1]. Growth of *Aspergillus niger* is also inhibited by cystine and cysteine[2]. *Penicillium notatum* has also been described as susceptible to inhibition of respiration by cystine[3].

Some preliminary information about this inhibition in *O. graminis* var. *avenae* and *A. niger* (which both behave identically) was obtained during an attempt to correlate specificity of parasitism with metabolic differences and is reported here.

With both fungi substitution of 0·5 per cent ammonium nitrate by 0·5 per cent ammonium sulphate prevents inhibition. This protection is complete at 0·5 per cent and partial at 0·1 per cent ammonium sulphate. On adding 0·1 per cent potassium nitrate or potassium nitrite to the ammonium

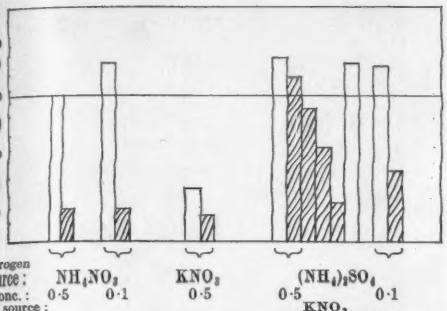

Fig. 1. Relative growth of *O. graminis* var. *avenae* showing effect on cystine inhibition of different sources of nitrogen: shaded, *with* 10^{-4} *M cystine; unshaded, without cystine*

sulphate medium full inhibition again occurs (Fig. 1). The *p*H does not vary appreciably during growth in these media.

2×10^{-4} *M* aspartic acid or glycine added to the ammonium nitrate medium fully prevents inhibition by 10^{-4} *M* cystine. Serine and alanine are partially effective, other amino-acids ineffective.

Molybdenum (as sodium molybdate) added to the ammonium nitrate medium fully prevents inhibition.

Cysteine inhibits respiration of *O. graminis* var. *avenae* and *A. niger* in manometer flasks containing phosphate buffer and 2 per cent glucose only. Inhibition occurs within 30 min. of adding 2 mgm./ml. cysteine. It is equally great with no nitrogen source or with nitrate and can again be prevented by addition of ammonium sulphate (20 mgm./ml.) in absence of nitrate or nitrite ions, or of aspartate or glycine (1 mgm./ml.) or molybdenum (0·02 mgm./l.).

Table 1. CONDITIONS AFFECTING INHIBITION

Ammonium	Nitrate or nitrite	Aspartate or glycine	Molybdenum	Inhibition
		Growth experiments		
+	+			+
+	−			−
+	+	+		−
+	+		+	−
		Warburg experiments		
−	−			+
+	+			+
+	−			−
+	+	+		−
+	+		+	−

Since the inhibition by cystine is as great in the absence of NO_3^- ion as in its presence the effect of nitrate on inhibition appears to be an indirect one, in that it prevents the NH_4^+ ion exerting its usual protective effect, perhaps by interference with uptake. These observations are summarized in Table 1. The type of inhibition indicated is a metal chelation effect connected with an early stage in nitrogen metabolism. The reversal of inhibition by molybdenum suggests an effect on enzymes of the nitrate-reducing sequence[4]; but this is difficult to reconcile with the results of the respiration experiment.

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BACTERIOLOGY

Formation of 'Protoplasts' in Mutant Strains of *Salmonella* induced by Galactose

IN 1932 Murase[1] in our laboratory isolated a peculiar mutant strain from aged broth cultures of *Escherichia coli* incubated at 37° C. This mutant had a characteristic colonial morphology on agar plates containing lactose, and because of its apparent resemblance to Massini's classical *Bacterium coli mutabile*[2] was called 'mutabile-type' by him. Since then, mutant strains having similar properties have been isolated from aged broth cultures of many strains of *E. coli*, *Shigella*, *Salmonella* and '*Paracolon*' groups, and many investigations on this particular type of mutation have been carried out in our laboratory. The results obtained may be summarized as follows[3,4].

(1) 'Mutabile-type' (*M*) mutants form convex colonies on ordinary nutrient agar plates, but when inoculated on agar plates containing galactose (or in some cases oligosaccharides containing galactose, namely, lactose or raffinose), they give rise to very flat colonies, with somewhat concave centres, and several papillæ appear on these colonies if incubation is prolonged.

(2) Wild-type strains are usually galactose-fermenting, but *M* mutants are consistently non-fermenters of galactose. (Massini's *B. coli mutabile* cannot ferment lactose, but it usually ferments galactose.)

(3) The growth of *M* mutants is strongly inhibited by the presence of even low concentrations of galactose, and this inhibition can be reversed by glucose. (Massini's *B. coli mutabile* is not inhibited by galactose.)

(4) Thus *M* mutants must be considered to be quite distinct in their nature from Massini's *B. coli mutabile*. Though *M* mutants were isolated from the aged broth cultures of many strains of the family Enterobacteriaceae, the frequency of their development varies greatly with strains used, conditions of incubation, and so on.

We have studied the mechanism of the inhibitory action of galactose on these mutants. The strain used was an *M* mutant of *Salmonella enteritidis* strain No. 11.

In the first series of the experiments, the mutant strain was grown with shaking in various liquid media—nutrient broth, salts–citrate–ammonium medium (Davis and Mingioli's minimal medium was modified by the substitution of 0·5 per cent sodium citrate for glucose), etc.—and D-galactose (Difco) was added to the final concentration of 0·1 per cent at the exponential phase of growth. Growth continued for about 30–90 min. at a slightly reduced rate, and then marked lysis was observed. But when the cells were kept in the non-growing condition, either by the addition of chloramphenicol (25 μgm./ml.) or by the removal of essential nutrients—by omitting citrate or ammonium salt from salts–citrate–ammonium medium and by omitting histidine in the case of a histidine-requiring mutant of this strain—galactose could not exert any effect on these mutant cells; no lysis was observed and the cells remained fully viable even at high concentrations of galactose. Thus the residual growth after the addition of galactose seemed to be a prerequisite for the extensive lysis to occur. This finding, together with the facts

that the *M* mutant cells grown in the presence of low concentrations of galactose show altered staining properties and degenerated forms[1,3,4], reminded us of some resemblance to the mode of action of penicillin on bacteria, in which case it has already been reported that: (1) penicillin induces lysis after some residual growth; (2) non-growing cells are resistant to the action of penicillin; (3) the cells grown in the presence of penicillin show various degenerate forms.

In the case of penicillin it was also reported that, when added to the suspension of *E. coli* growing in suitable hypertonic media, the bacterial cells are converted into the so-called 'protoplasts'[5,6]; spherical, osmotically fragile, yet viable (if appropriately treated) bodies. So the effect of galactose on *M* mutant cells was tested using a hypertonic medium. *M* mutant cells were grown in ordinary nutrient broth and in 'Carbowax-magnesium broth' (broth supplemented with 7·5 per cent (w/v) 'Carbowax 4,000' and 0·01 *M* magnesium sulphate)[7], and galactose (0·1 per cent) was added at their exponential phase of growth. As seen in Fig. 1, 'Carbowax 4,000' with magnesium ions completely prevented lysis induced by galactose. When these cells were examined under a phase-contrast microscope it was discovered that, 2–3 hr. after the addition of galactose, most of the cells in 'Carbowax'-magnesium broth were transformed into large, spherical bodies (Fig. 2), indistinguishable from the 'protoplasts' of this strain obtained by the action of penicillin in the same medium. If these 'spherical bodies' were diluted

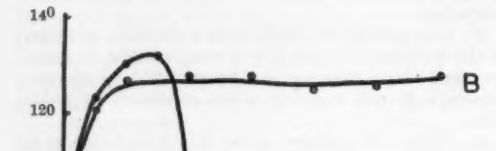

Fig. 1. Lysis of *M* mutant cells by galactose and its protection by 'Carbowax 4,000' and magnesium sulphate. Cells were incubated at 37° C. with gentle shaking either in nutrient broth (*A*) or in 'Carbowax'-magnesium broth (*B*). Optical density was measured at 660 mμ and expressed as relative values. The time of addition of galactose is shown as zero time

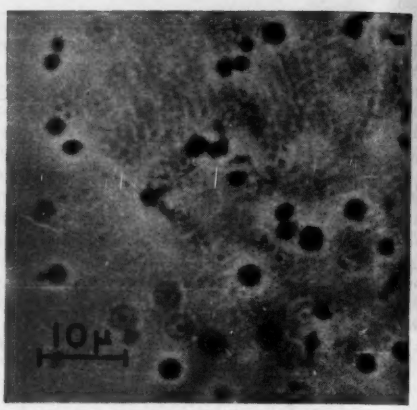

Fig. 2. 'Spherical bodies' of *M* mutant cells induced by galactose. *M* mutant cells were incubated for 2 hr. in 'Carbowax'-magnesium broth containing 0·1 per cent galactose

with distilled water, rapid clearing was observed, indicating their osmotic fragility. In order to confirm this finding, they were diluted serially either with distilled water or 'Carbowax'-magnesium broth, and 1 ml. aliquots of their $1 : 10^{5-7}$ dilutions were mixed in Petri dishes with molten 'Carbowax'-magnesium broth agar at 45° C. After overnight incubation, it was found that, when diluted with distilled water, they produced only $1 \cdot 9 \times 10^{-2}$ the number of colonies produced when they were diluted with 'Carbowax'-magnesium broth. In the control experiment with intact cells of this strain no difference in viable counts was observed between these two diluents.

Results similar to those described above were also obtained with an *M* mutant of a strain of *Salmonella typhimurium*. As in the case with penicillin[5], the most plausible explanation of the action of galactose is the inhibition of some intermediate process of cell-wall synthesis, but other possibilities remain which cannot be excluded at present. These points are now under investigation, and will be reported later with the details of the present study.

Thanks are due to Prof. D. Ushiba and Dr. K. Kinjo for their encouragement during this work.

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Isolation of Two Types of *Pasteurella haemolytica* from Sheep

In the course of studies on *Pasteurella haemolytica* isolated from cases of ovine pneumonia and septicæmia it has proved possible to place each strain examined so far into one of two main groups which, though closely similar, are distinguishable by certain *in vitro* characteristics. The occurrence of two types as described in this communication appears to be a different phenomenon from the colonial variation of

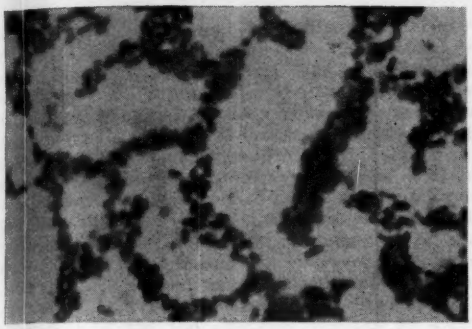

Fig. 1. Smear of *T* strain made in distilled water. (× 750)

Past. haemolytica recently described by Biberstein *et al.*[1]. For convenience the two forms will be referred to here as *T* strains and *A* strains, and a description of some distinguishing features is now given.

T Strains. 24 hr. colonies on blood agar measure up to 2 mm. in diameter. When viewed by transmitted light they are seen to possess large dark brown centres, the colour fading markedly towards the peripheries. When smears are made in distilled water from smooth colonies the bacteria generally show a strong tendency to become arranged in the lace-like pattern depicted in Fig. 1. This pattern is readily seen under the low power of the microscope. Smears made in saline show even dispersal of organisms.

Fermentation reactions are carried out in the medium recommended by Bosworth and Lovell[2]. This consists of peptone water containing 10 per cent broth with 7·5 per cent bromthymol blue and 1 per cent of the fermentable substance. The only tubes considered as positive are those which become completely yellow. All strains give a positive reaction in trehalose fermentation medium after two days incubation. The reaction in arabinose medium is negative up to the tenth day.

Growth curves in broth cultures inoculated with single colonies reach their maximum levels at about the sixth hour of incubation. The viable counts of such cultures then fall relatively slowly up to the twenty-fourth hour.

T strains are only moderately sensitive to the action of penicillin *in vitro*.

A Strains. Colonies growing on blood agar often tend to be rather smaller than *T* colonies. When viewed by transmitted light they show an even lightish-grey colour. There is sometimes a small, clearly demarcated central thickening. Smears made in distilled water usually show even dispersal of bacteria and a number of weakly staining 'ghost' forms.

All strains give a positive reaction in arabinose fermentation medium by the seventh day of incubation but remain negative in trehalose up to the tenth day.

Growth curves are different from those of *T* strains when broths are inoculated with comparable numbers of viable *A* organisms. Similar maximum viable counts are again obtained at about the sixth hour and the difference occurs afterwards as a result of the rapid and marked reduction in numbers of living *A* bacteria. At the twenty-fourth hour of incubation the differences in viable counts between *A* and *T* strains are only occasionally less than ten-fold and usually much greater. At this time there is no appreciable difference between turbidities of *A* and *T* broth cultures, neither is there any evidence of excessive clumping of bacteria. The *p*H of twenty-four hour *A* broth cultures is consistently slightly higher than that of *T* cultures.

A strains are considerably more sensitive than *T* strains to the action of penicillin *in vitro*.

Source of cultures. All 15 strains isolated from different outbreaks of lamb septicæmia[3] were of the *T* variety. No *A* strains have as yet been obtained from typical septicæmias. More than 20 *A* strains were derived in pure culture from sheep pneumonias. Four cases of pneumonia have been encountered in which mixtures of *T* and *A* strains were isolated from lung tissue, the liver, spleen and heart blood being sterile. In each of these cases *A* organisms predominated although the numbers of *T* organisms present were considerable.

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Production of 5-Keto-gluconic Acid by a Species of *Pseudomonas*

IN the latest edition of "Bergey's Manual of Determinative Bacteriology"[1], several authors are cited as supporting the claim that *Pseudomonas* strains which attack glucose do so oxidatively with the production of gluconic and 2-keto-gluconic acids, whereas *Acetobacter* strains, many of which are morphologically similar to members of the *Pseudomonas*, oxidize glucose to gluconic and 5-keto-gluconic acids.

In a recent study carried out at the Torry Research Station, Aberdeen, on some fifty *Pseudomonas*-like strains of bacteria isolated by previous workers[2–4] from fish, it was found that two of these strains produced 5-keto-gluconic acid from the oxidation of glucose. In the usual peptone water plus 1 per cent glucose medium, a strong acid (but no gas) reaction was given on 3-days incubation at 30° C. These cultures reduced Benedict's reagent in a few minutes at 25° C.—a feature, according to Militzer[5], characteristic of 5-keto-gluconic acid.

The products of glucose oxidation were separated by ascending chromatography on Whatman No. 1 paper (10 in. × 10 in.), using the solvent system of McFarren *et al.*[6] (ethyl acetate/pyridine/water, 25 : 30 : 15); 5-keto-gluconic acid ran as a strongly reducing spot at R_F 0·08, easily identified with the aniline oxalate reagent of Hough *et al.*[7], with which it gives a strong yellow spot, on heating for 5 min. at 105° C. With this reagent, gluconic acid gives no reaction, and 2-keto-gluconic acid forms an intense red spot. Only the two cultures which reduced Benedict's reagent at 25° C. gave this characteristic spot.

When cultured in 0·5 per cent peptone water containing 0·5 per cent ethanol, previously sterilized by Seitz filtration, neither strain produced acid or gas, even on prolonged incubation for 3 weeks at 30° C., although growth of both was excellent after

3 days. A strain of *Acetobacter aceti* cultured in this same medium produced acid in 3 days at 30° C.

Neither strain produced pigment on any medium, but morphologically were typical *Pseudomonas* strains; they were Gram-negative, polar flagellate bacilli, attacking glucose only under aerobic conditions, using the technique developed by Hugh and Leifson[8].

Biochemically, in some fifty tests, the two strains differed from each other with respect to the following reactions: tri-butyrin hydrolysis; fucose utilization; reduction of nitrate and growth in litmus milk. In addition, one strain grew at temperatures of 0–37° C., the other 0–30° C.

It is considered that, in view of their overall similarity to each other, they should be considered strains of the same *Pseudomonas* species; and since no description of such a species appears to exist in the most recent edition of "Bergey", it may well turn out to be a new one.

A full description of the morphology and biochemistry of this species will be published at a later date.

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Synthesis of Deoxyribonucleic Acid by Phage-infected *Escherichia coli* in the Presence of Mitomycin C

In a previous communication Shiba *et al.*[1] presented evidence that synthesis of deoxyribonucleic acid in *Escherichia coli B* was completely inhibited in the presence of mitomycin *C*, while ribonucleic acid and protein formation were unaffected as compared with that of a culture not exposed to the antibiotic. This communication shows that the impaired synthesis of deoxyribonucleic acid in cells treated with mitomycin *C* can be promptly restored by infection with bacteriophage *T2r*.

The crystalline mitomycin *C* used in these experiments was supplied by the Kyowa Fermentation Industry Co., Ltd., Tokyo, through the courtesy of Dr. S. Shiba of this University. Determinations of deoxyribonucleic acid, ribonucleic acid and protein were carried out by the diphenylamine, orcinol and Folin reactions, respectively.

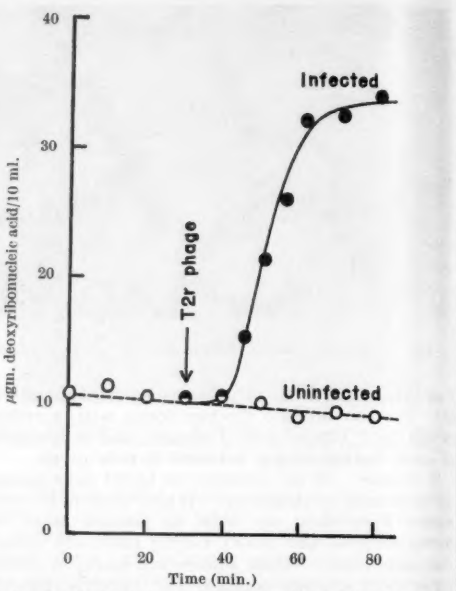

Fig. 1. Synthesis of deoxyribonucleic acid of *T2r*-infected or uninfected cells in the presence of mitomycin *C*. Cells harvested during the logarithmic phase were resuspended in fresh medium containing 10 μgm./ml. of mitomycin *C* at a concentration of 5×10^8 cells/ml., and incubated at 37° C. with shaking. After 30 min., one portion of the bacterial suspension was infected with a five-fold multiplicity of *T2r* phage, and another portion was incubated without infection as control. 10 ml. aliquots of the suspension were taken at the intervals shown and analysed for deoxyribonucleic acid

Cells grown in a glucose – salts synthetic medium with aeration were harvested during the logarithmic phase, and resuspended in a similar fresh medium. Tubes containing 10 ml. of the cell suspension (series *A*, 5×10^8 cells/ml.; series *B*, 5×10^8 cells plus $2{\cdot}5 \times 10^9$ *T2r* phage per ml.; series *C*, 5×10^8 cells plus 1×10^5 *T2r* phage per ml.) with various levels of mitomycin *C* as shown in Table 1 were incubated with shaking at 37° C. for 30 min. Series *A* (uninfected cells) and series *B* (infected cells) were subjected to the assay of nucleic acids and protein. Viability of the cells and infectivity of phage were measured by plating the sample of series *C*.

As shown in Table 1, exposure of a growing culture of uninfected cells to 10 μgm./ml. of mitomycin *C* caused selectively an inhibition of the net synthesis of deoxyribonucleic acid. The level of mitomycin *C* is much higher than that proposed by Shiba *et al.*[1], indicating that the strain used in these experiments (which was kindly furnished by Dr. A. D. Hershey) was more resistant to the antibiotic. While mitomy-

Table 1. Effects of Mitomycin *C* on the Synthetic Activities, Viability and Phage-producing Ability of *E. coli B*

Time of incubation (min.)	Concentration of mitomycin *C* (μgm./ml.)	Amount per tube: Deoxyribonucleic acid–phosphorus (μgm.)		Ribonucleic acid–phosphorus (μgm.)		Protein (mgm.)		No. of viable cells (per ml.)	No. of infective phage (per ml.)
		Uninfected	Infected	Uninfected	Infected	Uninfected	Infected		
0	0	12·5	13·0	62·8	62·5	0·82	0·80	$5{\cdot}1 \times 10^8$	$1{\cdot}0 \times 10^8$
30	0	18·6	37·4	93·6	66·4	1·18	1·00	$8{\cdot}5 \times 10^8$	$1{\cdot}1 \times 10^7$
30	0·1	18·7	37·2	96·5	68·9	1·20	1·01	$3{\cdot}0 \times 10^7$	$1{\cdot}2 \times 10^7$
30	1	14·2	36·9	98·7	65·0	1·20	0·95	$5{\cdot}8 \times 10^6$	$6{\cdot}9 \times 10^6$
30	10	12·3	36·2	87·7	62·8	1·18	0·98	$2{\cdot}0 \times 10^6$	$2{\cdot}4 \times 10^6$
30	100	12·1	21·4	69·2	60·2	1·07	1·00	$<1{\cdot}0 \times 10^6$	$<2{\cdot}0 \times 10^6$

cin *C* completely inhibited the formation of deoxyribonucleic acid in uninfected cells, its synthesis in cells infected by bacteriophage *T2r* could proceed without any inhibition under the same conditions. In addition, synthesis of deoxyribonucleic acid was resumed upon infection of bacteria pretreated with mitomycin *C* by bacteriophage (Fig. 1). Notwithstanding the increase in deoxyribonucleic acid in cells infected by bacteriophage *T2r*, it was found that the phage titre after incubation at the same level of mitomycin *C* was only about 20 per cent of the control (Table 1). Although the values of phage titre given in Table 1 were for an actual multiplicity of infection of 1 (average multiplicity of 0·0002) compared with 5 for the chemical results, we have obtained similar results for phage production at the higher multiplicities.

These results are reminiscent of the facts that bacteria damaged by ultra-violet irradiation[2] or mustard treatment[3] can recover their ability to synthesize deoxyribonucleic acid when infected with phage. However, in the case of inhibition by mitomycin *C*, removal of the antibiotic is not required to permit the infected bacteria to synthesize deoxyribonucleic acid. Therefore, it is possible that an alternative pathway of formation of deoxyribonucleic acid, resistant to mitomycin *C*, may be present in the infected cells.

We wish to express our appreciation to Prof. H. Kikkawa and Dr. B. S. Strauss for their interest and encouragement in this work.

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Synthesis of Cellulose in Ethanol Extracts of *Acetobacter xylinum*

FORMATION of bacterial cellulose in cell-free fractions of homogenates of *Acetobacter xylinum*, supplemented by either adenosine triphosphate[1,2] or uridine diphosphoglucose[3], has recently been reported. Such homogenate fractions are necessarily complex, and unequivocal identification of the immediate precursor of cellulose might be easier if a cell-free extract of cultures of this bacterium, which retains the capacity to form cellulose, could be prepared. This communication describes the preparation of such an extract.

Cells free from cellulose were prepared as described by Hestrin and Schramm[4], except that they were not dried from the frozen state but stored as a suspension in phosphate citrate buffer, *p*H 6·0, 0·01 *M* in phosphate, 0·003 *M* in citrate. The cells from 50 ml. of suspension, containing approximately 10^9 viable cells/ml., were washed once by centrifugation with 50 ml. of 0·02 *M* acetate buffer, *p*H 5·0, and the pellet redispersed in 6 ml. of the same acetate buffer. Three 2·5-ml. aliquots of the washed cell suspension were each incubated by shaking for 5 min. at 35° C. with 2·5 ml. of 0·02 *M* acetate buffer, *p*H 5·0, plus 0·8 ml. of 2 per cent glucose in the same buffer. After incubation, each aliquot was poured into 20 ml. of rapidly stirred absolute ethanol at room temperature and the cells removed by centrifugation immediately at 15,000*g*. The ethanolic supernatants were recentrifuged with a small amount of incinerated 'Celite 545' (Johns-Manville Co., New York). Finally, each aliquot was passed through a glass bacterial filter, Corning 60 *UF*, to remove any traces of cell debris or bacterial cellulose microfibrils.

The filtered extracts were treated as follows: aliquot *A* was evaporated to dryness at 40° C.; aliquot *B* was autoclaved for 15 min. at 17 lb. and evaporated as above; aliquot *C* was autoclaved, mixed with 1 ml. of the ultrafiltered supernatant of a suspension of washed *A. xylinum* cells which had been incubated for 5 min. in 2 per cent glucose, and then dried at 40° C.; finally, 1 ml. of the ultrafiltered supernatant was dried at 40° (aliquot *D*). The four residues were digested in 4 per cent sodium hydroxide for 10 min. at the temperature of boiling water[1,3,4], to remove a fraction of the non-cellulosic substance, diluted and the insoluble material centrifuged for 15 min. at 15,000*g*. Pellets were resuspended in 2 ml. of water and 0·05 ml. of the suspension placed on films of 'Formvar' floating on water. After suitable dialysis to remove residual sodium hydroxide, films carrying drops were mounted on grids, dried, shadowed with palladium–gold at an angle of 15° and examined in an electron microscope. Representative electron micrographs from each aliquot are shown in Fig. 1. The remainder of the pellet from each aliquot was washed thoroughly and hydrolysed in a sealed tube at 100° in 5 per cent sulphuric acid for 16 hr. The hydrolysate was neutralized with the ion-exchange resin 'Amberlite *MB* 1' (Rohm and Haas) and then chromatographed in butanol/pyridine/water (10 : 3 : 3). Free sugars were detected with alkaline silver nitrate. Aliquots *A* and *C* showed only one compound, which moved at the same rate as standard glucose. Only traces of this compound were detectable in aliquot *B* and none from *D*. Autoradiographs of chromatograms from a variety of

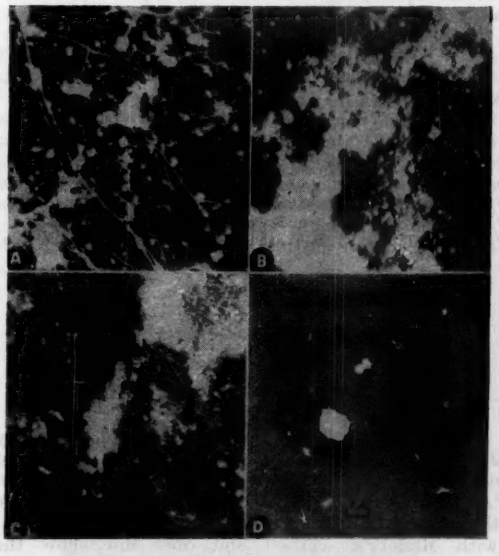

Fig. 1. Electron micrographs demonstrating formation of cellulose microfibrils from ultrafiltered ethanol extracts of active *Acetobacter xylinum* cultures: equal magnifications. Description of treatment of individual aliquots given in text

solvents, of ethanol extracts of active cultures metabolizing glucose uniformly labelled with carbon-14, so far have shown in these preparations no spots corresponding in position to those for cellobiose, cellotriose, cellotetrose, uridine diphosphoglucose or uridine diphosphate.

The fibrillar material from aliquot *A* (Fig. 1) is resistant to sodium hydroxide, yields only glucose as a component neutral sugar and has the typical morphology of bacterial cellulose microfibrils. It is formed from a precursor soluble in 80 per cent ethanol, during the evaporation of the extract, when the solution becomes predominantly aqueous. This formation of fibrillar material is almost prevented by prior autoclaving of the extract, but may be restored by addition of a portion of the extracellular medium of active cells. The precursor of cellulose microfibrils in the ethanol solution is therefore not destroyed by autoclaving for 15 min., but some accelerator of the process of microfibril formation must be. Presumably this accelerator is an enzyme. The presence of a few microfibrils in aliquot *B* indicates that the inactivation of the enzyme is not quite complete during this time. That the microfibrils do not come from the ultrafiltered supernatant of active cells is shown by the photograph of the grid from aliquot *D*. The presence of a substantial fraction of sodium hydroxide-resistant, non-dialysable, non-fibrillar material in each of the aliquots from ultrafiltered solutions should be noted because of its implications for interpretation of tracer experiments.

These results show: (*a*) 80 per cent ethanol extracts of active *Acetobacter xylinum* cells contain a compound which is converted rapidly to cellulose microfibrils when placed in water; (*b*) formation of cellulose microfibrils from this compound occurs in the complete absence of bacterial cell walls, as previously suggested[5]; (*c*) formation of microfibrils is accelerated by a heat-labile, extracellular substance in the medium of an active culture, presumably an enzyme. The results indicate also that neither uridine diphosphoglucose nor short β-glucosan chains are the immediate precursors of bacterial cellulose.

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BIOLOGY

Ultrastructure of Nucleoli in Oocytes of *Patella coerulea*

A special nucleolus, called 'Primärnucleolus' by Jörgensen[1], is always present during the growth of oocytes of *Patella coerulea*, while other nucleoli, called 'Amphinucleoli' by the same author gradually make their appearance. The 'Primärnucleolus' stains[2] red with Mallory's method and does not show the nucleolonema of Estable and Sotelo[3], while the 'Amphinucleoli' stain red at first, become blue later, show nucleolonemal elements and finally adhere to the nuclear membrane, where they gradually disappear. Previous research[4] suggested that this transition from red to blue might be due to a passage from a dense to a fluid state, which allows nucleolar substances to pass the nuclear membrane. No explanation was given of the presence of the nucleolonema in amphinucleoli and of its absence from the primary nucleolus. Electron microscope observations have been undertaken in order to check these results.

Fragments of the female gonad of *Patella coerulea* were fixed in a 1 per cent solution of osmic acid (buffered by Palade's method) and were embedded in a mixture of *n*-butyl and *n*-methyl methacrylate and sectioned with a Sjöstrand microtome. Preparations and observations were made at the Centre for Electron Microscopy at the University of Padua with a Siemens 'Elmiskop' I*a* apparatus. Throughout oocyte growth the primary nucleolus remains comparatively compact (Fig. 1) and does not present any particular structure which can be identified with the nucleolonema. It is composed of dark granules with a medium diameter of about 150 A., surrounded by granules of a lighter colour of approximately the same medium diameter (Fig. 1). These granules are more dense at the periphery. The outer surface of the primary nucleolus is not uniform, but shows strands extending into the nucleoplasm. These strands are composed of the above granules, which are also found in more or less conspicuous groups at a certain distance from the nucleolus. The same ultrastructure is shown by smaller nucleoli that are scattered inside the nucleus: they are amphinucleoli at the beginning of their formation[2].

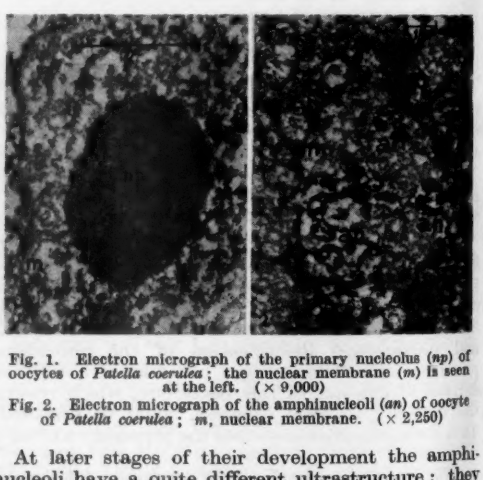

Fig. 1. Electron micrograph of the primary nucleolus (*np*) of oocytes of *Patella coerulea*; the nuclear membrane (*m*) is seen at the left. (× 9,000)

Fig. 2. Electron micrograph of the amphinucleoli (*an*) of oocyte of *Patella coerulea*; *m*, nuclear membrane. (× 2,250)

At later stages of their development the amphinucleoli have a quite different ultrastructure: they are then composed of rather thick and dark granules surrounding cavities of varying size (Fig. 2). The cavities correspond to intranucleolar vacuoles (these are also evident in later cytological preparations); the granules seem to be due to the aggregation of very small granular elements, the presence of which can also be observed in other regions of the same nucleoli. The outer surface of the amphinucleoli is more regular than the surface of the primary nucleolus.

Previous results obtained by platinum impregnation[2] are thus confirmed: during the growth of the oocyte of *Patella coerulea*, nucleoli of two types are present; one type shows evident nucleoolnemal elements, but the other type shows none.

Wischnitzer[5] observed with an electron microscope that the nucleolus of oocytes of *Triturus viridescens* "appears to maintain a compact consistency, but along the periphery strands project in all directions". He observed also that the nucleolus is formed by granules with an average diameter of about 150 A., surrounded by a matrix of lighter colour. André[6] also found that nucleoli of *Tegenaria parietina* oocytes are formed of numerous granules (100 A.) which are crowded together and form masses 0·1–0·2μ thick at the periphery. These masses are also found at a distance from the nucleolus. No mention is made of any threadlike structure resembling a nucleolonema. Finally, Serra[7], after an extensive comparative examination of nucleolar inclusions of plant meristem, oocytes of *Helix aspersa* and *Cepaea nemoralis*, and *Chironomus* salivary glands, reached the conclusion that "the nucleolonema is of the same rank as the vacuoles or other nucleolar differentiations: it is not a permanent structure in the nucleus nor does it necessarily exist in every nucleolus at all times".

However, according to Estable and Sotelo[3], the nucleolonema ought to be considered as a constant element of cellular structure. The above-mentioned results, as well as my own observations, lead to the conclusion that this is not so.

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Lens Cells of the Calf in Continuous Culture

Human and animal cells of various types in continuous culture are useful for studies of cellular biology and virus-cell interactions[1]. The need for strains of primary epithelial cells suggested the calf lens as a suitable tissue for investigating the possibility of establishing such cells in continuous culture. On December 28, 1956, both eyes were removed from a 3-months-old, male calf immediately after the death of the animal. Within 5 min. after enucleation, the lenses were removed from the eyes and were washed repeatedly with Hanks's balanced salt solution. The anterior capsule was dissected by circular incision posterior to the equator and the stroma was removed from the capsule; the epithelium remained attached to the capsule. The capsule was supplied with 2 ml. of growth medium. The latter consisted of Hanks's solution, 30 per cent calf serum inactivated at 56° C. for 30 min., 0·5 per cent lactalbumin hydrolysate and 5,000 units of penicillin and 5 mgm. of dihydrostreptomycin/100 ml. The lens capsule was gently pipetted up and down in a coarse pipette so that small fragments, about 1 mm. in diameter, were obtained. The fragments of both lens capsules were planted without plasma in two screw-cap bottles of 200-ml. size. They were allowed to be attached to the glass for 3 min. Afterwards, the flasks were provided with 4 ml. of growth medium and they were incubated stationary at 36° C. After 7 days, 4 ml. of fresh growth medium was added per flask without removal of the old medium. Thereafter, 75 per cent of the culture fluid was renewed every seventh day for two weeks and then every third or fourth day.

Four weeks after primary explantation, initial outgrowth from some explants became visible. One month later, occasional islands of transparent, scarcely visible cells were noted. Growth progressed at a very slow rate. Eleven weeks after the initial planting, cells of one flask were detached from the glass and transferred to a new flask. After this transfer the growth-rate increased and three sub-cultures were made by use of mechanical detachment at intervals of 2 weeks. Later, cells were detached with 0·02 per cent versene to start one sub-line and with 0·5 per cent trypsin to start another. Proliferation continued for 8 months, then began to decrease. For some months both sub-lines were maintained with difficulty and were finally reduced to one culture. The culture flask was then provided with medium containing pooled fresh calf serum inactivated at 56° C. for 30 min. Thereafter, a marked growth response was noted, and the cells have continued to proliferate at a constant rate. At the present time, cultures are divided into 2–4 sub-cultures after 10–14 days of incubation. The calf lens cells (strain *T–5a*) have been maintained through 44 passages for two years.

No alterations in the appearance of the cells have been observed throughout the period of cultivation. Microscopic observation of the cells shows that they are 8 to 12 times larger than other cells in continuous culture maintained in our laboratory: HeLa, human kidney and reticulosarcoma[2], mouse and rabbit kidney. Morphologically, the size and the shape of *T–5a* cells are similar to those of surviving epithelium of bovine lenses described by van den Heuvel[3]. No characteristic type of cell has been observed; some cells are polygonal, others are pyramidal, and a number are irregular in shape. The nuclei are oval and contain several nucleoli. Long mitochondria are conspicuous throughout the cytoplasm. Intercellular bridges between cells are regularly observed (Fig. 1). In contrast to other stable cell strains, division of calf lens cells is rarely seen. Possibly these cells require a relatively short period to complete mitosis. The *T–5a* cells are remarkably resistant to the action of trypsin. After incubation for 5 hr. at 37° C. in 0·5 per cent trypsin solution, no injurious effect was noted. Attempts to cultivate the cells in a growth-medium containing less than 20 per cent calf serum and to adapt the cells to a medium of which the serum component is of heterologous origin (human and horse serum) have failed consistently. Likewise, negative results were obtained when an attempt was made to store the cells by freezing by the methods described by Scherer and Hoogasian[4].

Fig. 1. Culture of lens cells of the calf (strain *T–5a*) from the twenty-fifth sub-culture; phase-contrast. (× 560)

Poliovirus types 1, 2 and 3 did not produce degeneration of the *T*–5*a* cells and did not multiply in these cells either in primary culture or after passages. Adenovirus types 1–5, 7*a* and 8 have been propagated serially in the cells through 5 passages with at least a 10^8-fold increase in infectivity and with reproduction of cytopathic changes similar to those in HeLa cells. The viruses caused a widespread cytopathic effect at the third to fifth day after primary inoculation. On subsequent passages, the changes were observed in a limited number of cells from the seventh to tenth day of incubation and they did not progress to complete destruction of the cultures. It is possible that the early cytopathic effect after primary inoculation is of a toxic nature, not necessarily associated with virus multiplication[5].

With the method described, we have succeeded in subcultivating cells from the lenses of two other calves (*T*–5*b* and *T*–5*c* cells). Three attempts to grow lens cells of the calf in continuous culture were unsuccessful. The *T*–5*b* and *T*–5*c* cells have been maintained through 18 subcultures for one year. No differences in morphology, growth, resistance to polioviruses and susceptibility to adenoviruses between *T*–5*a*, *T*–5*b* and *T*–5*c* cells were observed.

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Effect of Controlled Lighting on Production Characters in the Fowl

King[1] recently reported that a combination of restricted lighting during rearing and increasing lighting during the laying season results in increased egg production in laying pullets. Morris and Fox[2] have suggested that sexual maturity is influenced by change of length of day rather than by the absolute amount of light the birds receive during rearing. They have already published interim results[3] of an experiment which supports this contention. Their experiment also shows that decreasing lighting during the rearing of pullets hatched in December delays maturity, increases weight of eggs, but does not lower total egg production during the first sixteen weeks of lay.

Similar work, to test experimental lighting techniques, was started last year on three farms; at Glinton, Northants, at Lucan, Eire, and at Stewarton, Scotland. At all locations there are two deep-litter cabins, one with windows and one without, which can be controlled for ventilation and temperature. Each cabin contains 120 small pens, 8 ft. × 6 ft.

To apply King's method in the field it is necessary to have windowless intensive rearing houses. At the present time few people in Britain have the required facilities and it would be useful to know if increasing lighting during laying alone would produce at least part of the increase in production reported by King. This type of treatment and King's complete treatment are being tested alongside conventional lighting treatments. The treatments applied at the three locations are summarized in Table 1. The birds were reared and housed under identical conditions at each location except for the lighting treatments. There is considerable uniformity of results from several strains within each location.

The results from Stewarton, after the birds have been in lay for five months, show that the attainment of peak production is delayed, and although percentage hen-housed egg production is now higher in treated birds there is little chance of them having a higher hen-housed egg production at the end of the laying season. They have dropped too far behind in the first three months of lay to be able to catch up on the controls. At Glinton (Table 2), where the birds were housed earlier, and have been in lay six months, the treatment delayed maturity (25 per cent production) by 36 days. This could be a combination of increased age at first egg and subsequent delay in attaining normal rate of lay. The results in other respects are similar to those from Stewarton. Apart from maturity and production there are some advantages for increasing lighting. First, there is evidence that mortality is reduced. Secondly, the coefficient of variation of egg production is reduced, which on the basis of some justifiable assumptions means that heritability estimates will be increased. This could lead to improved efficiency in selection experiments carried out under these conditions. Thirdly, during the first two or three months of lay there is evidence that egg weight is increased.

At Lucan, results (Table 3) show that restricted lighting during rearing, in combination with either increasing or constant lighting during laying, leads to all the advantages listed above. Further, though maturity (25 per cent production) is delayed about 6 days compared with birds reared on natural day-length, percentage hen-housed production rises more

Table 1. Treatments Applied

Location			0–23 weeks	Housed 23 weeks onwards		
Stewarton	Control Treated	+ −	Natural day-length	14 hr. a day 6 hr. a day at housing increasing by 20 min. a week		
			0–16 weeks	Housed 16 weeks onwards		
Glinton	Control Treated	+ −	natural day-length	14 hr. a day 6 hr. a day at housing increasing by 10 min. a week		
			0–4 weeks	4–12 weeks	12–20 weeks	Housed 20 weeks onward
Lucan	Control Treated Control Treated	++ −+ +− −−	24 hr. light a day 24 hr. light a day	natural day-length natural day-length	natural day-length 6 hr. light a day natural day-length 6 hr. light a day	14 hr. a day 6 hr. a day at housing increasing by 15 min. a week

Table 2. AVERAGE RESULTS FOR STRAIN *A* AT GLINTON

	Control +	Difference	Treated −
Date hatched	19/2/58		19/2/58
Date housed	11/6/58		11/6/58
Number housed	76		74
Age at 25% hen-housed egg production in days	159	36	195
Hen-housed egg production to 31/12/58	84·4	12·1*	72·3
Coefficient of variation of hen-housed egg production (%)	12·3	7·5	4·8
Hen-housed egg production December 1958 (%)	46·9	13·8	60·7
Mortality (%)	3·9	1·2	2·7
Egg weight, oz./doz. October	24·0	0·7*	24·7
Egg weight, oz./doz. November	24·0	1·4†	25·4
Egg weight, oz./doz. December	24·7	0·8†	25·5

* Significant, $P < 0.05$. † Significant, $P < 0.01$

Table 3. AVERAGE RESULTS FOR STRAIN *M* AT LUCAN

	Control +	−	Difference	Treated −	−
Date hatched	28/4/58 to 12/5/58			28/4/58 to 12/5/58	
Date housed	26/9/58			26/9/58	
Number housed	485			486	
Age at 25% hen-housed production in days	162		6	168	
Hen-housed egg production to 31/12/58	42·3		8·5†	50·8	
Coefficient of variation of hen-housed egg production (%)	18·0		5·8	12·2	
Hen-housed egg production for December 1958 (%)	56·8		18·0	74·8	
Mortality (%)	2·9		1·5	1·4	
Egg weight, oz./doz. October	19·4		0·6*	20·0	
Egg weight, oz./doz. November	22·2		0·3	22·5	
Egg weight, oz./doz. December	23·4		0·3	23·1	

* Significant, $P < 0.05$. † Significant, $P < 0.01$.

sharply and reaches a higher peak. At the end of three months in lay, total egg production and percentage hen-housed production are higher in the birds which received restricted lighting.

If the hypothesis put forward by Morris and Fox[2] is correct, it is the change in length of day from one day old to housing, rather than restriction of light, which has brought about the consequent improved production. The pullets at Lucan, in fact, dropped from 24 hr. light a day during the first month to 6 hr. a day at housing. According to the formula given by Morris and Fox[2] this should delay maturity by 13 days compared with the control group. Their formula was calculated from data on Rhode Island Red × Light Sussex chickens and refers to age at first egg. The present observations refer to age at 25 per cent production, and, therefore, a comparison is not justifiable. However, the amount of delay may depend on whether the change in light during rearing is applied gradually, or, as in the experiment reported here, in a two-phase reduction.

Records from the birds at Glinton, Lucan and Stewarton will be collected for a ten-month laying season. The details and results of the experiments will then be published in full elsewhere, at a later date.

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Sex Incidence of Vascular Lesions in Aging Rats in Relation to Previous Pregnancies

Wexler and Miller[1], in describing the production of severe arterial sclerosis in rats treated with corticotrophin, noted the greater susceptibility of their 1-year old breeding females to these lesions. We have found that during and between pregnancies, human uterine arteries undergo profound alterations, including 'reduplication' of internal elastic laminæ and massive intimal mucopolysaccharide accumulation. That alterations occur in pregnant women, not only in uterine but also in other arteries throughout the body, is suggested by the relationship which has been shown between pregnancy and aortic aneurysms or ruptures[2]. We therefore decided to investigate the spontaneous incidence of vascular injuries in breeding and non-breeding male and female stock rats in our colony. These animals consumed our standard diet, which permits normal growth, breeding performance and life-span.

The incidence of aortic and coronary mineralization in 81 untreated stock rats over the age of 500 days is shown in Table 1. It will be seen that these lesions were absent among male rats, occurring only in females ($P < 0.01$), and that among the latter the lesions were much more common in breeders than in non-breeders ($P < 0.02$). These discarded breeding females had all had 3–7 litters each.

Table 1. INCIDENCE OF BOTH AORTIC AND CORONARY MINERALIZATION IN STOCK RATS
(No. of rats with lesions/total rats in group)

Age group (days)	Male		Female	
	Non-breeders	Breeders	Non-breeders	Breeders
501–800	0/10	0/5	0/13	6/15
801–1,240	0/18	0/5	2/7	4/8
Total	0/28	0/10	2/20	10/23

Mineralization (calcium and/or iron 'coating') of the internal elastic membranes of smaller vessels, such as the coronary, mesenteric and uterine arteries, was common in these discarded breeding females, as was the deposition of iron in the basement membranes of the proximal convoluted tubules of the kidneys, and even in the depot fat cells. The aortæ (ascending, thoracic and abdominal) were, however, most severely affected in all instances (Figs. 1 and 2), and showed rigidity and calcification, and even cartilage and bone formation, together with the intimal and medial fibrosis, ectasia and heavy mucopolysaccharide accumulations mentioned by Wexler and Miller in their animals treated with corticotrophin. Calcification, with heavy mucopolysaccharide accumulations and cartilage formation was common in the papillary muscles of both ventricles, and this was associated with moderate fibrosis of the underlying myocardium. Increases in pericoronary reticulin were notable and, although gross infarcts were not found, patchy increases in myocardial reticulin were common. However, the coronary arteries themselves were not as seriously damaged in our untreated old breeding females as was apparently the case in Wexler and Miller's animals treated with corticotrophin; coronary thromboses were not seen by us, although the coronary vessels were unduly dilated, rigid and mineralized in our breeding females.

These lesions occurring spontaneously in breeding females were indistinguishable from those described

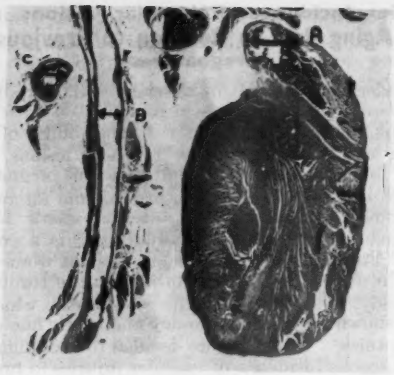

Fig. 1. Heart, ascending aorta (*A*) and thoracic aorta (longitudinal, *B*, and transverse section, *C*) to show cardiac size and aortic diameter (compare with Fig. 2). Stock non-breeding female 797 days old. Stained von Kossa. (× 3·6)

in healing arteries after short-term toxic doses of calciferol[3–5] as was the close association between mucopolysaccharide accumulations and mineral deposition and fibrosis. Selye[6] has shown that corticoids markedly increase the susceptibility of the coronary arteries in rats to similar acute traumata. The corticotrophin treatment applied by Wexler and Miller may thus have aggravated pre-existing cardiovascular lesions in their breeding females.

Closer attention to endocrine and other factors influencing the integrity of arterial walls during growth and under various physiological conditions, including pregnancy, certainly seems merited. Sex hormones have been shown to regulate circulating fibrin and fibrinolysins[7], anticoagulants, and even more powerful thrombolytic substances perhaps appearing in the circulation during pregnancy. The ovarian hormone relaxin, known to promote lysis of ligaments and even bone in œstrogen-primed animals, may affect arterial structure during pregnancy. The effects of endocrine glands, and of pregnancy in particular, in 'protecting' some arteries while promoting degeneration and subsequent intimal fibrosis, thrombosis or even rupture in others, thus merits experimental study and epidemiological surveys in man.

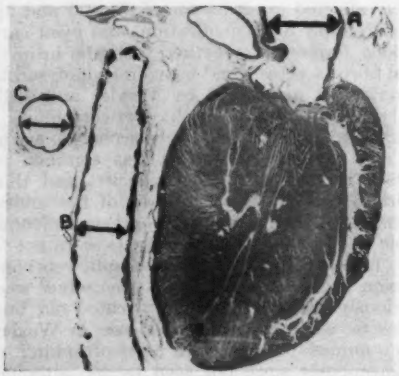

Fig. 2. Section similar to that in Fig. 1 but from 636-day-old female that had had five litters. Note enlarged heart, grossly dilated ascending aorta (*A*) and thoracic aorta (*B* and *C*). The black material in the aorta (*A*, *B* and *C*) is von Kossa-positive material (calcium); iron was also demonstrated in these areas. (× 3·6)

We wish to thank the Schlesinger Organization and the Wellcome Trust for generous financial assistance, and Mrs. P. Kruger, Miss A. Killerby and Miss M. D. Carolan for their assistance.

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Amniotic Fluid and the Fœtal Lung

Of the problems associated with development of mammalian fœtal lungs, and with the changes they undergo just before and at birth, many are controversial, but Gairdner[1], in his careful review of the subject, states that "the weight of evidence supports the view that the fœtus normally inhales and absorbs liquor amnii".

During an investigation into the microscopic appearances of rat fœtal lungs following a variety of experimental procedures, I have been able to make an observation which not only throws considerable doubt on the hypothesis of Potter *et al.*[2] and Policard *et al.*[3] that the inhalation of amniotic fluid is a normal and necessary morphogenetic factor in the expansion of the alveolar spaces, but which also provides positive evidence of actual production of fluid by the fœtal lung, such as has occasionally been postulated.

Rat fœtuses were operated on *in utero* between the seventeenth and nineteenth days of gestation (the day of finding sperm in the vaginal smear being counted as day 1). The uterus was afterwards opened under pentothal anæsthesia in a warm saline bath some hours before the time for normal parturition on the twenty-second day. With minimal handling, and provided the placental circulation remained intact, both normal and experimental fœtuses invariably lay inert in the saline; in this state they were injected with either morphine sulphate or D-tubocurarine chloride in order to prevent the subsequent occurrence of gasping movements, which are capable in themselves of altering profoundly the appearances of intra-thoracic viscera. Fixation in Helly's fluid was followed by paraffin-embedding and serial-sectioning of the neck and thorax.

The aim of the first operation was to transect the trachea through an orientated stab-incision in the uterine wall. Survival-rates of operated fœtuses were as follows:

2-day survival	10 out of 17 operated
3-day survival	9 out of 14 operated
4-day survival	11 out of 36 operated

Preparation and study of the serial sections is now in progress. Operated animals show retardation in body-growth compared with normal controls, so that a twenty-second-day experimental fœtus usually corresponds approximately to a twenty-first-day control. Most of the 16 specimens so far studied in detail show little evidence of damage at the site of

Fig. 1. (× 8)

incision. In some cases this may be because the transection was incomplete; but many of these specimens show marked accumulation of cells and cell-debris in the pharyngeal lumen: it is well known that fœtal tissues show remarkable powers of regeneration, especially when, as in these cases, the edges of the wound are left in close apposition.

Fig. 1 shows the thoracic viscera in transverse section at a standard level in such a fœtus on the twenty-second day, 4 days after the neck was incised. The microscopic appearances of the lungs are very similar to those in a normal twenty-first-day fœtus. Fig. 2 is a similar section from a litter-mate which had been operated on at the same time. In this specimen the margins of the incised trachea had failed to re-unite; in the serial sections there is a gap of 240μ between the blind ends of the proximal and distal portions of the trachea. The lungs were therefore isolated from the amniotic sac. Despite the small size of the animal and of its lungs, the latter are expanded to a degree greater than in a normal twenty-second-day fœtus. There is, in addition, a marked effusion into the pleural cavity, which is perhaps reasonably interpreted as the result of transudation from the over-filled alveolar spaces.

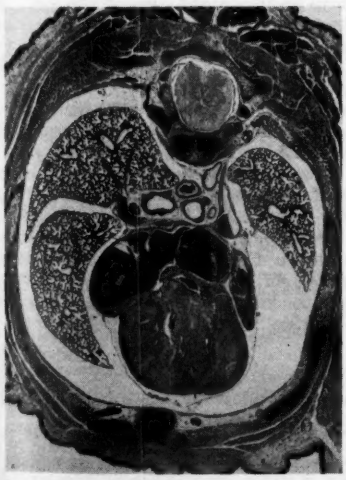

Fig. 2. (× 8)

It is concluded that the fœtal lung is capable of producing whatever fluid is necessary to fill the enlarging alveolar spaces. The fluid appears to be produced in excess, and this would favour the view of Whitehead *et al.*[4] that the lung is itself one of the sources of amniotic fluid. This conclusion is not necessarily true, however, and it is considered likely that any excess fluid would normally enter the pharynx and be swallowed by the fœtus.

This interpretation of experimental findings would appear to give a rational explanation for the similar appearances reported by Potter *et al.*[5] in a case of a human accessory lung without connexion to the trachea, and by Jost and Policard[6] in rabbit fœtuses previously subjected to decapitation. These authors were unable to account for their findings on the basis of their published views on the morphogenetic factors involved in normal fœtal lung-growth and expansion.

Work on this series, and other experiments on fœtal lungs, are still in progress.

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Testing Populations of Beet Eelworm, *Heterodera schachtii* Schmidt, for Resistance-breaking Biotypes, using the Wild Beet (*Beta patellaris* Moq.) as Indicator

SOME species of wild beet, including *Beta patellaris*, are resistant to beet eelworm. The roots of *B. patellaris* are invaded by larvæ, a small proportion of which develop into mature males, but usually no mature females are produced[1].

Dunnett[2], Jones[3], Goffart[4] and Huijsman[5] found that some populations of the potato root eelworm, *H. rostochiensis* Woll., from various parts of Britain, Germany and Peru reproduce in the wild potato, *Solanum tuberosum* sub sp. *andigena*, which had been resistant to the populations previously tested. Populations of beet eelworm from various parts of England were therefore tested on *B. patellaris* to see whether any could be found able to produce cysts on this species.

Eight populations were tested from the following districts: Iffley, Oxon.; Soham, Cambs.; Waterbeach, Cambs.; Lakenheath, West Suffolk; Chatteris, Isle of Ely; Spalding, Lincs; Oxlode, Isle of Ely; Yeovil, Somerset. Plants of *B. patellaris* were grown singly in potting compost in 6-in. pots, plunged in gravel. Replication was three-fold and 4,000 hatched larvæ were added per pot.

Ten weeks after adding the larvæ, the tops were removed and the soil and roots air dried. Cysts were recovered by elutriating the soil[6] to ensure that all cysts present were detected.

A single cyst was found from one plant in each of the Spalding and Yeovil populations and two cysts from one plant in the Oxlode population. This is the first record of the development of females on *B. patellaris*.

Thus, although there is no evidence of resistance-breaking biotypes occurring on the same scale as found with *H. rostochiensis*, individual females able to develop on *B. patellaris* exist and their potential importance should be recognized. Further investigations are needed on the extent to which these biotypes can give rise to populations containing a larger proportion of such individuals. As one of the possibilities considered in breeding sugar beet resistant to beet eelworm is to introduce genes for resistance from *B. patellaris*, a situation favouring the multiplication of these biotypes might result from growing sugar beet × *B. patellaris* crosses in the field.

This work was carried out at the School of Agriculture, Cambridge, and financed by the Sugar Beet Research and Education Committee.

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Persistence of Tomato Aucuba Mosaic Virus in Dried Leaf Tissue

In December 1934, in order to keep in a convenient form some material of the strain of tomato aucuba mosaic virus with which I had been working at Rothamsted Experimental Station, some leaves of infected tomato plants were dried in air and put in an envelope.

After I came to this Department, some of this material was used from time to time for inoculating plants in connexion with the experiments being carried out here. The original virus has been transmitted from plant to plant by juice-inoculation for the past 24 years.

The envelope containing the original material (of December 11, 1934) was kept in a cupboard in the laboratory, and it was thought that it would be interesting to see what had happened to the infectivity of the virus after a period of desiccation of 24 years.

A small leaflet weighing 10 mgm. was crushed in a mortar and 10 ml. of water added and the whole thoroughly mixed. After 1 hr., an interval to allow of complete wetting of the dry material, about 0·1 ml. of liquid was rubbed on to each of 16 leaves of plants of *Nicotiana glutinosa*.

The control material was a fresh leaflet of tomato of approximately the same size as that selected for the first experiment. This was infected with the same strain of virus which through the years has been inoculated from tomato to tomato plant.

This material was again thoroughly macerated, mixed with 10 ml. water and left for 1 hr. at laboratory temperature. Similar amounts of liquid were inoculated by rubbing with a finger into each of 16 leaves of *N. glutinosa* plants. The results were as follows:

Material	Total number of lesions on 16 leaves
Dry material (Dec. 24, 1934)	2 + 1 (doubtful)
Control material (fresh)	652

The experiment was repeated using 200 mgm. of dried material in 10 ml. of water. Similar amounts were rubbed on to each of 14 leaves of *N. glutinosa* plants when it was found that, after an interval of 5 days, a total of 15 + 2 doubtful lesions had developed on the 14 leaves.

This same material was left for 24 hr. to allow further wetting of the dried material if this were necessary, and five lesions were found on fifteen leaves of *N. glutinosa* after inoculation and treatment similar to that noted above.

It appears, therefore, that while the activity of the tomato aucuba mosaic virus is very greatly reduced by desiccation and storage in a dry state for 24 years, there is still a little residual activity even after that period of time.

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A Third Species of 'Pepper' in West Africa

Two workers on the peppers (*Capsicum*), Smith and Heiser[1], have recently discovered that among the peppers of Central and South America a new species of pepper, *Capsicum sinense* Jacq. had been present within the species *C. frutescens* L. This new species, which could not at first be detected when *C. frutescens* was itself separated from *C. annuum* L., is now recognizable by the 3–5 flowers at each node, the declinate pedicels, and the circular constriction at the base of the calyx in fruit, quite apart from the sterility barrier between it and the four other species of pepper in Central and South America, namely, *C. pubescens* R. and P., *C. annuum* L., *C. pendulum* Willd., and *C. frutescens* L.

This discovery calls for a verification in other parts of the world where the peppers flourish to see if this new species could be found there. West Africa is certainly one of the areas that are rich in peppers which form an important item of the local dish; but only two species *C. annuum* L. and *C. frutescens* L. have been described[2]. For well over a year now, collection of local varieties of peppers have been made in West Africa with special reference to Ghana. More than sixty varieties have so far been cultivated and described (unreported), and the results show that the new species *C. sinense* is present also in West Africa. Two distinct varieties of this species have so far been distinguished, and these will be described separately elsewhere. Nothing has been found among the collection to answer to any of the other two species in Central and South America. This third species of pepper, *C. sinense*, in West Africa will have to be included in the "Flora of West Tropical Africa" now under revision.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, April 20

BRITISH SOCIETY FOR THE PHILOSOPHY OF SCIENCE (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. W. C. Salmon: "The Concept of Empirical Verifiability".

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (at 14 Belgrave Square, London, S.W.1), at 5.30 p.m.—Annual General Meeting, followed by Dr. F. Call: "The Chemical Control of Nematodes in Soil".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London W.C.2), at 6 p.m.—Prof. J. B. Speakman: "Research in Wool". (First of three Cantor Lecturers. Further lectures on April 27 and May 4.)

Monday, April 20—Tuesday, April 21

ELECTRICAL ASSOCIATION FOR WOMEN (in London)—Thirty-fourth Annual Conference. Theme: "Education in a Scientific Age". Speakers: The Rt. Hon. Reginald Maudling, M.P., The Countess Mountbatten of Burma, C.I., G.B.E., D.C.V.O., Ll.D., and Lady Bragg, M.A., J.P. Chairman: The Viscountess Kilmuir, D.B.E.

Monday, April 20 (at the Federation of British Industries, 21 Tothill Street, London, S.W.1), from 2 p.m. to 5 p.m.—Branch Officers' Session.

Tuesday, April 21 (at the Connaught Rooms, Great Queen Street, London, W.C.2), at 10.30 a.m.—Annual General Meeting.

Monday, April 20—Friday, April 24

INDUSTRIAL PHOTOGRAPHIC AND TELEVISION EXHIBITION AND CONFERENCE (at the Royal Albert Hall, London).*

Tuesday, April 21

ROYAL AERONAUTICAL SOCIETY (at the Institution of Mechanical Engineers, Birdcage Walk, Westminster, London, S.W.1), at 9.45 a.m. —All Day Discussion on "The Structural Effects of Kinetic Heating".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Problem of Maintenance of Electronic Equipment in the Process Industries", opened by Dr. G. Morris and Mr. N. T. C. McAffer.

Wednesday, April 22

INSTITUTE OF FUEL (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Mr. T. C. Bailey: Presidential Address.*

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Dr. D. J. E. Ingram: "The Application of Magnetic Resonance to Solid State Electronics".

WOMEN'S ENGINEERING SOCIETY, LONDON BRANCH (at Hope House, 45 Great Peter Street, London, S.W.1), at 7 p.m.—Mr. A. B. McKenzie: "Development of the Gas Turbine Aero Engine".

Thursday, April 23

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Meeting for Election of Foreign Members, followed by Miss Elizabeth Rhodes and Prof. A. R. Ubbelohde, F.R.S.: "Melting and Crystal Structure. Effects of Thermal Transformations of Ionic Crystals on their Ultra-violet Absorption"; Mr. B. Szigeti: "Higher Order Terms in the Dielectric Constant of Ionic Crystals".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Mr. S. H. U. Bowie: "The Uranium and Thorium Resources of the Commonwealth".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Sir David Brunt, F.R.S.: "The Geophysical Year 1957–58" (Fiftieth Kelvin Lecture).

BRITISH GLACIOLOGICAL SOCIETY (at Bedford College, Regent's Park, London, N.W.1), at 6 p.m.—Annual General Meeting. Mr. C. W. M. Swithinbank: "Sea Ice in the North West Passage over the last 58 Years".

ROYAL AERONAUTICAL SOCIETY (at the Institution of Mechanical Engineers, Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. W. H. Stephens: "Earth Satellites".

Friday, April 24

LINNEAN SOCIETY OF LONDON (in the Lecture Theatre, British Museum (Natural History), Cromwell Road, South Kensington, London, S.W.7), from 10.30 a.m. until 6 p.m.—Meeting on "Comparative Studies in Ultrastructure". Speakers include Dr. George E. Palade, Dr. Sanford L. Palay, Dr. J. Hanson, Dr. H. E. Huxley, Dr. J. Lowry and Mr. Andrew F. Huxley, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. T. C. Macnamara and Mr. B. Marsden: "Engineering Aspects of Commercial Television Programme Presentation".

UNIVERSITY OF LONDON (in the Anatomy Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. O. Heckmann (University of Hamburg): "Some Current Observing Programmes of the Hamburg Observatory". (First of three Special University Lectures in Astronomy. Further lectures on April 27 and 29.)*

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Annual Meeting.

Friday, April 24—Saturday, April 25

ROYAL SOCIETY OF MEDICINE, ENDOCRINOLOGY SECTION and the SOCIETY FOR ENDOCRINOLOGY (with the participation of the SOCIETY FOR THE STUDY OF FERTILITY, the MEDICAL SECTION of the BRITISH DIABETIC ASSOCIATION, the LONDON THYROID CLUB, and the ENDOCRINE CLUB, GLASGOW, at the Royal Society of Medicine, 1 Wimpole Street, London, W.1)—Joint Endocrine Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURERS (honours graduates in physics or chemistry) IN POLYMER CHEMISTRY—The Registrar, Manchester College of Science and Technology, Manchester 1 (April 25).

SECRETARY (preferably with a professional qualification and experience in grant-aided work) OF THE WELSH PLANT BREEDING STATION, to be responsible for the administration, accountancy and office organization—The Registrar, University College of Wales, Aberystwyth (April 25).

LECTURER, and a LECTURER (Grade B) IN THE MATHEMATICS DEPARTMENT—The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1 (April 27).

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF ZOOLOGY—The Registrar, The University, Liverpool (April 28).

SENIOR PRINCIPAL SCIENTIFIC OFFICER (with a first- or second-class honours degree in chemistry, chemical engineering or physics, or equivalent, or high professional attainment, and practical experience in mineral dressing and/or hydrometallurgy) at Warren Spring Laboratory, D.S.I.R., Stevenage, Herts, to lead a section carrying out research on mineral processing—The Civil Service Commission, 17 North Audley Street, London, W.1, quoting Ref. S.4964/59 (April 28).

ASSISTANT LECTURER IN PHYSICS—The Secretary and Registrar, University College of North Wales, Bangor, North Wales (April 30).

ASSISTANT LECTURERS or LECTURERS IN CIVIL OR MECHANICAL ENGINEERING—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (April 30).

GEOLOGIST (with an honours degree in geology requiring a four-year course at a recognized university, and preferably with previous experience) with the Government of Southern Rhodesia—The Secretary (R), Rhodesia House, 429 Strand, London, W.C.2 (April 30).

LECTURER IN PHYSICS—The Registrar, King's College (University of Durham), Newcastle-upon-Tyne (April 30).

LECTURER (with a special knowledge or experience of physical methods, and the ability to teach to honours standard, and to initiate and supervise research) IN PHARMACEUTICAL CHEMISTRY—The Secretary-Treasurer, Royal College of Science and Technology, Glasgow (April 30).

PLANT PHYSIOLOGIST or BOTANIST (with an honours degree in botany, and preferably postgraduate experience in plant physiology, biochemistry, or with herbicides) to evaluate new herbicides in greenhouse and pot culture studies and to determine their phytotoxic properties; and an AGRONOMIST or HORTICULTURIST (with an honours degree in agriculture or science with postgraduate training or research experience), to take charge of part of the field evaluation programme on new herbicides—Dr. E. K. Woodford, A.R.C. Unit of Experimental Agronomy, Department of Agriculture, Oxford (April 30).

ASSISTANT LECTURER IN PHYSICS—The Registrar, King's College (University of London), Strand, London, W.C.2 (May 1).

ASSISTANT LECTURER or LECTURER (well qualified in systematic geography, and preferably first-hand knowledge of a region other than Western Europe) IN GEOGRAPHY—The Assistant Registrar, The University, Edmund Street, Birmingham 3 (May 2).

LECTURER (with special qualifications and research experience in fruit growing) IN HORTICULTURE—The Registrar, Room 22 (O.R.B.), The University, Reading (May 2).

LECTURER IN PHYSIOLOGY—The Registrar, King's College (University of London), Strand, London, W.C.2 (May 4).

ASSISTANT LECTURER (with special interests in crop production and the mechanization of crop production) IN AGRICULTURE—The Registrar, Wye College (University of London), near Ashford, Kent (May 5).

CHAIR OF PHYSICS—The Registrar, University College of North Staffordshire, Keele, Staffs (May 9).

LECTURER IN THE DEPARTMENT OF MATHEMATICAL PHYSICS—The Secretary, The University, Edinburgh (May 9).

SENIOR LECTURER and a LECTURER IN THE DEPARTMENT OF BIOCHEMISTRY—The Secretary, The University, Edinburgh (May 9).

ASSISTANT LECTURER or LECTURER IN ZOOLOGY with special reference to Entomology—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (May 11).

LECTURER or ASSISTANT LECTURER IN MATHEMATICS at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 15).

LECTURER (preferably with interests in sedimentology or geophysical methods) IN GEOLOGY at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, May 15).

ASSISTANT LECTURER IN PHILOSOPHY—The Assistant Registrar, The University, Edmund Street, Birmingham 3 (May 16).

ASSISTANT LECTURER or LECTURER (with a special interest in some aspect of parasitology) IN THE DEPARTMENT OF AGRICULTURAL AND FOREST ZOOLOGY—The Secretary and Registrar, University College of North Wales, Bangor (May 16).

NAPIER CHAIR OF ASTRONOMY—Joint Clerk to the University Court, College Gate, St. Andrews (May 16).

DEMONSTRATOR (with interests in palæontology, stratigraphy, sedimentary petrology or structural geology) IN GEOLOGY—Dr. I. D. Muir, Department of Mineralogy and Petrology, The University, Downing Place, Cambridge (May 23).

WRIGHT–FLEMING CHAIR OF IMMUNOLOGY in St. Mary's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 25).

CHAIR OF PHYSICS in the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, May 30).

CHAIR OF PHARMACOLOGY—The Registrar, The University, Leeds 2 (June 1).

CHAIR OF AGRICULTURE in the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, June 15).

ASSISTANT FARM MANAGER (with at least a diploma in agriculture), to assist in running a medium-sized mechanized rice farm in Gambia, and to act as Manager when the Farm Manager is on leave—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/12/011.

ASSISTANT LECTURER (Grade B) IN GEOLOGY, to teach up to the standard of the B.Sc. (General) degree—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

ASSISTANT PROFESSOR OR ASSOCIATE PROFESSOR OF MATHEMATICS—The President, Memorial University of Newfoundland, St. John's, Newfoundland, Canada, and The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

GEOLOGISTS (with a degree of a recognized university with either first- or upper second-class honours in geology, two years approved postgraduate experience, and preferably some specialization in mining geology) in the Geological Surveys Department, Federation of Malaya—The Recruitment and Personnel Division, Malaya House, 57 Trafalgar Square, London, W.C.2.

LECTURER (Grade II) IN THE DEPARTMENT OF ORGANIC CHEMISTRY—The Registrar, The University, Bristol 8.

RESEARCH ASSISTANTS (2) (with experience in aeronautical or electronic engineering or in physics) to undertake interesting theoretical and experimental work IN THE DEPARTMENT OF AERONAUTICAL ENGINEERING—The Secretary and Registrar, The University, Southampton.

SCIENTIFIC OFFICER IN THE VIROLOGY DEPARTMENT, for work on plant virus diseases—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, by Dundee.

SENIOR BOTANIST (with a good honours degree in botany and considerable experience in crop breeding, preferably tropical crops) in Tanganyika, for production of improved varieties of crops for irrigation schemes with particular reference to dry season crops, and to lead a team of three breeders—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/8/024.

SENIOR PHYSICS MASTER—The Headmaster, School House, Cranbrook, Kent.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Texas Instruments Limited, Bedford. Semiconductor Application Report, Vol. 1, No. 4: D.C. Power Supply Circuits Using Silicon Rectifiers. Pp. 35. (Bedford: Texas Instruments, Ltd., 1959.) [112

Anti-Locust Bulletin No. 33: Field Observations on the Behaviour of Hoppers of the Red Locust (*Nomadacris septemfasciata* Serville.) By Dr. R. F. Chapman. Pp. ii+51. (London: Anti-Locust Research Centre, 1959.) 9*s.* 6*d.* [122

Ministry of Labour and National Service. Practices Impeding the Full and Efficient Use of Manpower: Report of an Inquiry undertaken by the National Joint Advisory Council. Pp. 16. (London: H.M. Stationery Office, 1959.) 1*s.* net. [122

Bulletin of the British Museum (Natural History). Entomology. Vol. 7, No. 9: A Study of the New Zealand Chironomidae (Diptera, Nematocera). By Paul Freeman. Pp. 393–437+plate 11. 12*s.* 6*d.* Geology. Vol. 3, No. 10: Blue-Green Algae from the Middle Devonian of Rhynie, Aberdeenshire. By W. N. Croft and E. A. George. Pp. 339–353+plates 41–44. 8*s.* (London: British Museum (Natural History), 1959.) [122

International Journal of Radiation Biology and related studies in Physics, Chemistry and Medicine, Vol. 1, No. 1 (January, 1959). Pp. 104. Price per part 20*s.* plus postage. Subscription per volume (4 issues) 75*s.* post free. (London: Taylor and Francis, Ltd., 1959.) [122

Proceedings of the Society for Psychical Research. Vol. 52, Part 188 (February, 1959): Dreaming and Some of Its Implications. By Prof. C. D. Broad. (Presidential Address, 1958.) Pp. 53–78. (London: Society for Psychical Research, 1959.) 2*s.* 6*d.*: 0.50 dollars. [192

University of Leeds. Annual Report of the Librarian, Session 1957–58. Pp. 12. (Leeds: Brotherton Library, The University, 1958.) [192

University of Birmingham: University Research Committee. Twenty-ninth Annual Report (Session 1957–1958). Pp. 108+1 plate. (Birmingham: The University, 1959.) [192

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Zweiter Katalog der Astronomischen Gesellschaft für das Aquinoktium 1950. Örter der Sterne bis zur neunten Grösse zwischen dem Nordpol und 2° südlicher Deklination abgeleitet aus photographischen Himmelsaufnahmen der Sternwarten Bergedorf und Bonn, unter Leitung von Richard Schorr und Arnold Kohlschütter. Elfter Band: Deklination +15° bis +20°. Pp. 276. (Bonn: Universitäts Sternwarte, 1957.) [102

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 39, (December, 1958): Large Population Gains in United States and Canada. Fatal Accidents Decrease in 1958. Large Death Toll Under Age 65. Cancer in Childhood. Pp. 12. (New York: Metropolitan Life Insurance Company, 1959.) [122

Western Region of Nigeria. Annual Report on the Forest Administration of the Western Region of Nigeria for the year 1956–57. Pp. iii+34. (Lagos: Government Printer, 1958.) 1*s.* [122

Institut de France—Académie des Sciences. Annuaire pour 1960. Pp. 250. (Paris: Gauthier-Villars, 1959.) [122

An Emerging Program of Secondary School Mathematics. By Max Beberman. (Inglis Lecture in Secondary Education, 1958.) Pp. viii+44. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1959.) 7*s.* 6*d.* net. [122

Union of South Africa: Department of Commerce and Industries: Division of Fisheries. Twenty-eighth Annual Report for the period 1st April, 1956 to 31st March, 1957. Pp. 160. (Reprint from *Commerce and Industry*, September, 1958.) (Pretoria: Government Printer, 1958.) [122

Commonwealth Scientific and Industrial Research Organization, Australia. Soil Publication No. 12: The Characteristics and Origin of Soils in the Coleraine District, Victoria. By G. Blackburn and T. L. Leslie. Pp. 47+1 map. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1958.) [182

East Africa High Commission. East African Industrial Research Organization Annual Report, 1957–1958. Pp. ii+18. (Nairobi: Government Printer, 1958.) Sh.2. [182

Annals of the New York Academy of Sciences. Vol. 75, Article 2: The Uterus. By Joseph T. Velardo, William B. Ober, Herbert C. Winston and 72 other authors. Pp. 385–1040. (New York: New York Academy of Sciences, 1959.) 7 dollars. [182

Indian Forest Records (New Series). Entomology. Vol. 9, No. 6: Some More Indian Geomatrid Larvae (Lepidoptera), with a Note on the Identity of Components of Various Groups of Setae. By Balwant Singh. Pp. ii+131–163+1 plate. (Delhi: Manager of Publications, 1957.) Rs. 1.50; 2*s.* 3*d.* [182

Proceedings of the Third Congress on Theoretical and Applied Mechanics, Bangalore, December 24–27, 1957. Pp. xi+362. (Kharagpur: Indian Society of Theoretical and Applied Mechanics, Indian Institute of Technology, 1958.) n.p. [182

Geological Society of South Africa. New Observations on the Ores of the Witwatersrand in South Africa and their Genetic Significance. By Prof. Paul Ramdohr. Pp. 50+61 plates. (Annexure to Vol. 61 of the *Transactions and Proceedings of the Geological Society of South Africa*.) (Johannesburg: Geological Society of South Africa, 1958.) [182

Research Bulletin of the Panjab University. No. 131 (Zoology): A Histological Study of the Brain, Optic Lobes and Thoracic Nerve Cord of *Petrobius brevistylis*, with special reference to the Descending Nervous Pathways. By R. C. Satija. Pp. 493–510+7 plates. Rs. 3/50. No. 132 (Zoology): Studies on the Course and Functions of the Giant Nerve Fibres from the Eye and the Tegumentary Nerve to the Central Nervous Cord in *Locusta migratoria*. By R. C. Satija. Pp. 511–519+2 plates. Rs. 1/75. No. 133 (Zoology): Cytological Studies in Heteroptera. 4: Chromosome Complement and Meiosis in Twenty-six Species of the Pentatomoidea, Lygaeoidea and Coreoidea, with a Consideration of the Cytological Bearing on the Status of these Super-Families. By Ram Parshad. Pp. 521–559. Rs. 5/23. No. 134 (Zoology): A New Genus of the Spiders of the Family Sparassidae. By Sukh Dyal. Pp. 561–566+1 plate. Rs. 1/36. No. 135 (Chemistry): Studies in Surface Chemical Reactivity and Surface Area of Suspensoids. Part 1: Methods of Estimation. By Balwant Rai Puri, J. Singh, D. D. Singh and Lekh Raj Sharma. Pp. 1–7. Rs. 1/32. No. 136 (Chemistry): Studies in Surface Chemical Reactivity and Surface Area of Suspensoids. Part 2: Relationship between Surface Reactivity and Surface Area of a Few Oxide Gels. By Balwant Rai Puri, H. Singh, D. D. Singh and Lekh Raj Sharma. Pp. 9–12. Rs. 0/89. (Hoshiarpur: Panjab University, 1957 and 1958.) [182

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